

3.0 Ground Water Monitoring

This section discusses ground water monitoring and presents interpretations resulting from these activities in 2006. Section 3.1 presents an overview of routine monitoring activities. Section 3.2 summarizes nonroutine monitoring activities. Discussion and interpretation of the results of ground water monitoring are provided in Section 3.3, which focuses on the water quality and flow at the more notable ground water contaminant plumes at the Site and the water quality and maintenance at the ground water treatment systems associated with contaminant plumes. The PLF and OLF are addressed in Section 3.4. Section 3.5 summarizes some of the ground water-affecting activities and events that took place, as well as selected studies performed on Site ground water. References are included in Section 8.0.

Appendix B.3 includes previously published Seasonal-Kendall (S-K) trend plots from the second quarterly report for 2006 (DOE 2006g) as well as these plots for the fourth quarterly report. Appendix A.3 contains water level data from 2006, and Appendix A.4 contains corresponding hydrographs.

Ground water was monitored in 2006 in accordance with the 2006 IMP (DOE 2006c, 2006d). The 2006 IMP dictates the monitoring and data evaluation reported herein; the 2007 Annual Report will comply with RFLMA.

The ground water section of this 2006 Annual Report is written with two primary objectives:

1. Provide summary discussion and interpretation of ground water results obtained in 2006 from IMP locations; and
2. Incorporate additional content that may be most relevant to long-term monitoring objectives at the Site.

Upon acceptance of RFLMA, the monitoring will be performed under Attachment 2 to that document (DOE 2007b).

In keeping with the annual report for 2005 (DOE 2006e), references to the Site and to the subject of ground water monitoring will honor the name (e.g., RFP, RFETS, and RFS) and form of the term (ground water vs. groundwater) used in each reference cited.

Note also that discussions of ground water analytical data are focused on the IMP-defined data set, which contains data from January 1, 2000, to the end of the reporting period—in this case, through December 31, 2006. In addition, unless otherwise noted these discussions consider only results from “Field” samples (previously referred to as “REAL” samples in the SWD)—not field duplicates or laboratory duplicates, for example—and data that are rejected or not validated are excluded. Those seeking additional detail in the analytical data are referred to previously published documents, such as the quarterly reports (DOE 2006f, 2006g, 2007d) and Appendix B.6.

3.1 Routine Ground Water Monitoring Activities of 2006

Routine activities of the ground water monitoring program in 2006 included sample collection, water level measurement, and well maintenance (particularly the development or redevelopment of monitoring wells).

The program also performed special, nonroutine monitoring discussed in Section 3.2 to support various objectives. Analytical data and other information generated via routine and nonroutine sampling have been reported in the corresponding quarterly reports (DOE 2006f, 2006g, 2007d) and Appendix B.6.

The network of monitoring wells did not change during 2006 (i.e., no additional wells were monitored, and none were removed from the network). However, physical conditions at one well did degrade over the course of the year. Monitoring at well 45605, installed within a slump block that developed over the course of the year south of former B991, was accelerated in order to collect more data before the well no longer functions. The slump is addressed in more detail in Section 3.5.1.

The ground water closure network devised by the IMP (K-H 2005d, DOE 2006c) is subdivided and categorized as shown in Table 3–1. A summary of additional modifications, as initially recommended by the Water Working Group and subsequently incorporated in Attachment 2 of RFLMA (DOE 2007b), is presented in Table 3–2. Upon acceptance and implementation of these recommendations, the well network would be reduced in size by roughly 20 percent.

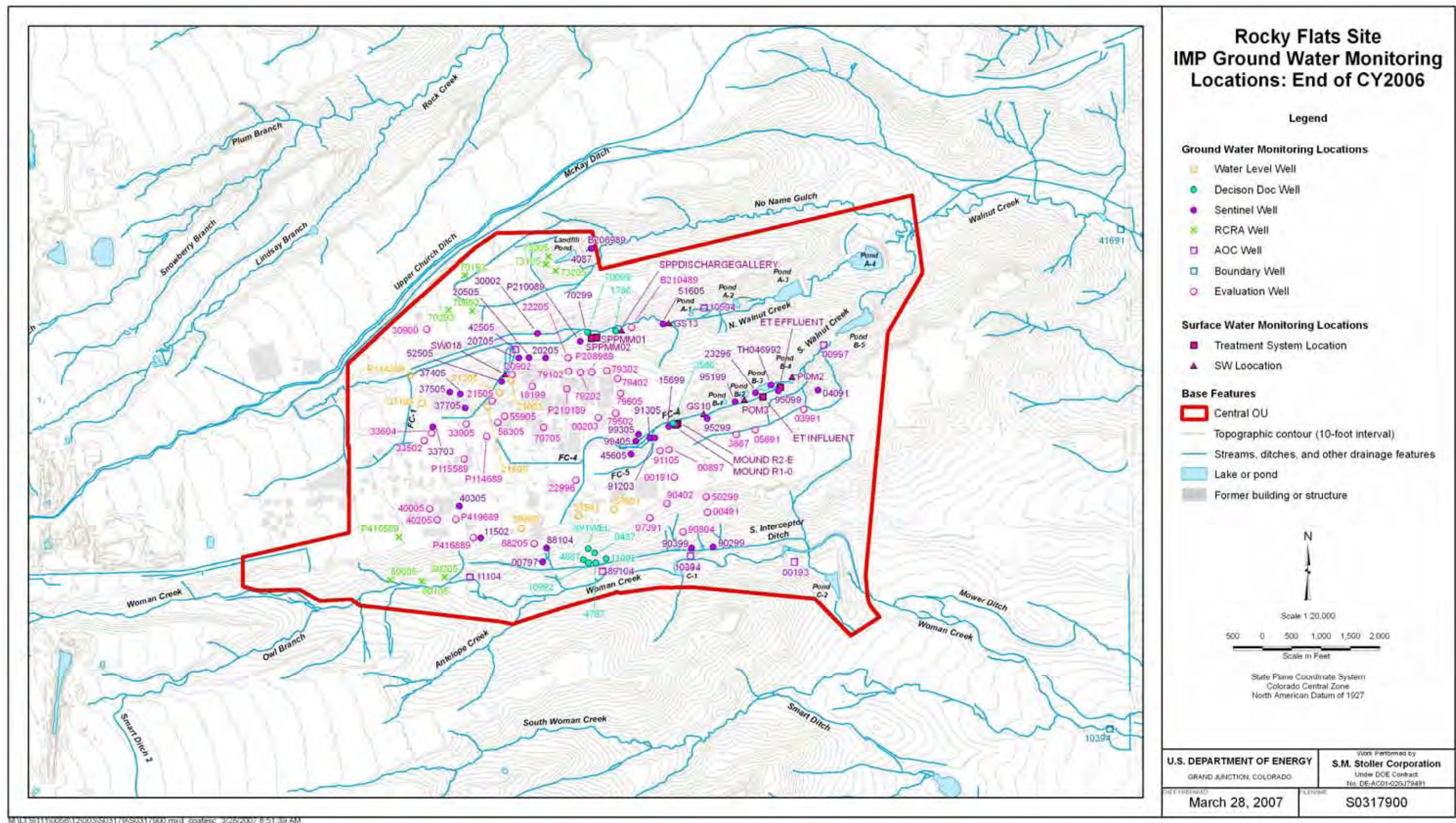


Figure 3-1. Rocky Flats Site IMP Ground Water Monitoring Locations: End of CY 2006

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Table 3–1. IMP Classifications for the 2006 Ground Water Monitoring Network (K-H 2006c)

Well Classification	General Objective	Number of Wells	Monitoring Frequency
AOC	Monitor ground water quality and water levels in a drainage downgradient of a contaminant plume or group of plumes	7	Semiannual (2x/year)
Boundary	Monitor ground water quality and water levels in Woman Creek and Walnut Creek drainages at eastern (downgradient) Site boundary	2	Annual (1x/year)
Sentinel	Monitor ground water quality and water levels near contaminant plume edges and in drainages	32	Semiannual (2x/year)
Evaluation	Monitor ground water quality and water levels in or near contaminant source areas and in the former Industrial Area	40	Biennial (1x/every 2 years)
RCRA	Monitor ground water quality and water levels upgradient and downgradient of the PLF and the OLF	10	Quarterly (4x/year)
Decision Doc	Monitor ground water quality and/or water levels in accordance with published decision documents	9	Varies
Water Level	Monitor ground water levels (not water quality) in areas lacking coverage or of special interest	26	Semiannual (2x/year)
Treatment System ^a	Monitor quality of ground water treatment system influent, effluent, and downgradient surface water	10	Semiannual (2x/year)
Surface Water Support ^a	Monitor quality of surface water downgradient of contaminant plume	2	Semiannual (2x/year)

^aTreatment System and Surface Water Support locations are not monitoring wells but are included for completeness.

Note: AOC = Area of Concern, RCRA = Resource Conservation and Recovery Act, Decision Doc = Decision Document.

Table 3–2. Additional Proposed Modifications to the Monitoring Network

Well / Location	Area	Current IMP Classification	Suggested Disposition
0487	OU1	Decision Document	Abandon
1786	SPPTS	Decision Document	Abandon
3586	MSPTS	Decision Document	Abandon
4787	OU1	Decision Document	Abandon
4887	OU1	Decision Document	Abandon
10992	OU1	Decision Document	Abandon
11092	OU1	Decision Document	Abandon
15199	MSPTS	Water Level	Abandon
15299	MSPTS	Water Level	Abandon
15399	MSPTS	Water Level	Abandon
15499	MSPTS	Water Level	Abandon
15599	MSPTS	Water Level	Abandon
15799	MSPTS	Water Level	Abandon
16199	MSPTS	Water Level	Declassify
16299	MSPTS	Water Level	Declassify
16399	MSPTS	Water Level	Declassify
16499	MSPTS	Water Level	Declassify
16599	MSPTS	Water Level	Declassify
70299	SPPTS	Decision Document	Abandon ^a
70799	SPPTS	Water Level	Declassify
70899	SPPTS	Water Level	Declassify
70999	SPPTS	Water Level	Declassify
71099	SPPTS	Water Level	Declassify
95699	ETPTS	Water Level	Declassify
95799	ETPTS	Water Level	Declassify
95899	ETPTS	Water Level	Declassify
SPPMM02	SPPTS	Treatment System	Replace with SPIN ^b
891WEL (replaces 891COLWEL)	OU1	Decision Document	Reclassify as Evaluation well (biennial, rather than quarterly)
51605 (replaces 1386)	SPPTS	Sentinel	Reclassify as Evaluation well (biennial, rather than semiannual)

Notes: Except as noted, these are recommended by the Water Working Group during development of the 2005 IMP.

^aWell 70299 and well 70099 were both considered for retention or abandonment. The Working Group recommended one be retained; well 70299 was ultimately selected. However, data evaluations indicate well 70099 responds more quickly to changes in water quality, and may be the best candidate for retention; therefore, well 70099 is proposed for retention and 70299 abandonment as indicated above.

^b(Not discussed during IMP development) SPPMM02 is intended to represent system influent. However, location SPIN more accurately represents this water, as it is the well in which the pump is located. The decision document predates installation of that well, and specifies influent sampling at nearby piezometer 71099 (a.k.a. SPPMM02).

OU1 = Operable Unit 1 (881 Hillside); SPPTS = Solar Ponds Plume Treatment System; MSPTS = Mound Site Plume Treatment System; ETPTS = East Trenches Plume Treatment System.

Declassify = remove from routine monitoring and eliminate monitoring requirements, but retain for troubleshooting purposes.

Table 3–3 presents the 2006 schedule for routine sample collection, a subset of which are summarized in Table 3–4 as those scheduled samples that were not successfully collected (e.g., due to dry conditions.) Corresponding analytical results are published in the associated quarterly reports (DOE 2006f, 2006g, 2007d) and Appendix B.6.

Table 3–3. Summary of Scheduled Routine Ground Water Sampling in CY 2006 (by Quarter)

Location		Analytes						
ID	IMP Class	VOC	U	Nitrate	Metals	Pu/Am	α/β	SVOC
0487	DD	1,2,3,4						
1786	DD		2,4	2,4				
3586	DD	2,4	2,4			2,4	2,4	
3687	E	2						
4087	S	2,4	2,4	2,4				
4787	DD	2,4						
4887	DD	2,4						
00191	E	2						
00193	AOC	2,4	2,4					
00203	E	2	2	2				
00491	E	2						
00797	S	2,4	2,4					
00897	E	2						
00997	AOC	2,4	2,4	2,4				
03991	E	2						
04091	S	2,4						
05691	E	2						
07391	E	2	2					
10304	AOC	2,4	2,4	2,4				
10394	B	2	2	2				
10594	AOC	2,4	2,4	2,4				
10992	DD	2,4						
11092	DD	2,4						
11104	AOC	2,4	2,4					
11502	S	2,4	2,4					
15699	S	2,4						
18199	E	2						
20205	S	2,4	2,4			2,4		
20505	S	2,4	2,4			2,4		
20705	S	2,4	2,4	2,4		2,4		
20902	E	2						
21505	E	2						
22205	E	2	2	2				
22996	E	2	2					
23296	S	2,4	2,4					
30002	S	2,4						
30900	E	2						
33502	E	2						
33604	E	2						
33703	S	2,4						
33905	E	2						
37405	S	2,4	2,4	2,4		2,4		
37505	S	2,4	2,4	2,4				
37705	S	2,4	2,4	2,4		2,4		
40005	E	2	2					
40205	E	2	2					

Table 3-3 (continued). Summary of Scheduled Routine Ground Water Sampling in CY 2006 (by Quarter)

Location		Analytes						
ID	IMP Class	VOC	U	Nitrate	Metals	Pu/Am	α/β	SVOC
40305	S	2,4	2,4					
41691	B	2	2	2				
42505	AOC	2,4						
45605	S	2,4						
50299	E	2						
51605	S		2,4	2,4				
52505	S	2,4						
55905	E	2	2	2				
56305	E	2	2	2				
70099	DD		2,4	2,4				
70193	RCRA	1,2,3,4			1,2,3,4			
70299	S		2,4	2,4				
70393	RCRA	1,2,3,4			1,2,3,4			
70693	RCRA	1,2,3,4			1,2,3,4			
70705	E	2	2					
73005	RCRA	1,2,3,4			1,2,3,4			
73105	RCRA	1,2,3,4			1,2,3,4			
73205	RCRA	1,2,3,4			1,2,3,4			
79102	E	2	2	2				
79202	E	2	2	2				
79302	E		2	2				
79402	E		2	2				
79502	E		2	2				
79605	E		2	2				
80005	RCRA	1,2,3,4			1,2,3,4			1,2,3,4
80105	RCRA	1,2,3,4			1,2,3,4			1,2,3,4
80205	RCRA	1,2,3,4			1,2,3,4			1,2,3,4
88104	S	2,4	2,4					
88205	E	2	2					
89104	AOC	2,4						
891WEL	DD	1,2,3,4						
90299	S	2,4						
90399	S	2,4						
90402	E	2						
90804	E	2						
91105	E	2						
91203	S	2,4						
91305	S	2,4	2,4	2,4				
95099	S	2,4						
95199	S	2,4						
95299	S	2,4						
99305	S	2,4	2,4	2,4				
99405	S	2,4	2,4	2,4				
B206989	S	2,4	2,4	2,4				
B210489	E		2	2				
P114689	E	2						
P115589	E	2						
P208989	E	2	2	2				

Table 3–3 (continued). Summary of Scheduled Routine Ground Water Sampling in CY 2006 (by Quarter)

Location		Analytes						
ID	IMP Class	VOC	U	Nitrate	Metals	Pu/Am	α/β	SVOC
P210089	S	2,4	2,4	2,4				
P210189	E	2	2	2				
P416589	RCRA	1,2,3,4			1,2,3,4			1,2,3,4
P416889	E	2	2					
P419689	E	2	2					
TH046992	S	2,4						
MOUND R1-0	TS	2,4	2,4			2,4	2,4	
MOUND R2-E	TS	2,4	2,4			2,4	2,4	
GS10	TS	2,4						
ET INFLUENT	TS	2,4						
ET EFFLUENT	TS	2,4						
POM2	TS	2,4						
SPPMM02	TS		2,4	2,4				
SPPMM01	TS		2,4	2,4				
SPP DIS GAL	TS		2,4	2,4				
GS13	TS		2,4	2,4				
POM3	SS	2,4						
SW018	SS	2,4						

Notes:

ID = Identification (name) of well/sampling location

IMP = Integrated Monitoring Plan

IMP classifications: AOC = Area of Concern; B = Boundary; S = Sentinel; E = Evaluation; DD = Decision Document;

RCRA = Resource Conservation and Recovery Act; TS = Treatment System; SS = Surface Water Support.

2 (or other numeral) = Analyte requested; if blank, analyte not requested

Table 3–4. Summary of Samples Not Successfully Collected

Location		Analytes						
ID	IMP Class	VOC	U	Nitrate	Metals	Pu/Am	α/β	SVOC
4087	S	2,4	2,4	2,4				
4787	DD	2,4						
4887	DD	2,4						
04091	S	4						
07391	E		2 ^a					
11092	DD	2,4						
73005	RCRA	3			3			
88104	S		4					
90299	S	2						
95199	S	4						
95299	S	2,4						
P416589	RCRA				3			
SPPMM02	TS		4	4				
GS13	TS			2				
POM3 ^b	SS	2,4						

Notes:

^aAnalyte successfully collected in 3rd quarter.

^bLocation is to be sampled in coordination with CDPHE, who did not request sampling in 2006.

Most unsuccessful attempts to collect samples were due to dry conditions.

ID = Identification (name) of well/sampling location

IMP = Integrated Monitoring Plan

IMP classifications: AOC = Area of Concern; B = Boundary; S = Sentinel; E = Evaluation; DD = Decision Document;

RCRA = Resource Conservation and Recovery Act; TS = Treatment System; SS = Surface Water Support.

2 (or other numeral) = Analyte requested during the quarter indicated by the numeral, but not successfully collected; if blank, analyte not requested.

3.2 Nonroutine Ground Water Monitoring Activities of 2006

Nonroutine ground water monitoring was performed in 2006 in support of several data needs:

- Confirmatory sampling
- Accelerated sampling
- Investigative sampling

Confirmatory samples were collected in 2006 from Boundary well 41601. The nitrate concentration in a sample from this well (located at the intersection of Walnut Creek and Indiana Street) was reported at 470 mg/L, which is several orders of magnitude higher than normal (it is typically much less than 1 mg/L). The concentration reported for the confirmatory sample, 0.024 mg/L (B-qualified—there was nitrate present in the blank), confirmed the 470 mg/L result to be an outlier. Therefore, that datapoint will not be used in water quality assessments at well 41691.

Accelerated sampling may be performed if a data need is urgent, or if there is reason to believe the location to be sampled will be inaccessible during its normally scheduled sampling. The latter was the case at well 45605, which is installed within the active slump that is associated with former French drain outfall location SW056, south of former B991. This slump was first identified in January 2006 (DOE 2006f, 2006g, 2007d). As the slump developed over the course

of the year, the condition of the well grew increasingly precarious. Sampling of the well was accelerated to enable the collection of additional water quality data should the well no longer function.

Investigative sampling may be performed when additional data needs are identified that will not be satisfied by the routine monitoring schedule. In 2006, this was most clearly applicable to the Solar Ponds Plume Treatment System (SPPTS). Water quality data collected after a valve adjustment in May 2005 showed elevated nitrate in the system effluent. Subsequent valve adjustments were made, and samples collected to track their effects on effluent water quality. While improved, nitrate treatment was still inadequate and additional measures were taken. Nonroutine samples were collected throughout these efforts to evaluate their effects on effluent water quality in general and nitrate concentrations in particular. The topic of the SPPTS is discussed in greater detail in Sections 3.3.2.3 and 3.5.2.

Another application of investigative sampling was the continuation of the no-purge sampling evaluation begun in late 2005 (see DOE 2006e for additional discussion). This topic is addressed in Section 3.5.2.

All Evaluation wells were scheduled for sampling in the second quarter of 2006. In some cases this could be considered nonroutine, as these wells are routinely sampled every other year and most had been sampled in 2005. However, in this case sampling of Evaluation wells in 2006 is considered routine sampling, and is summarized in Table 3–3 of Section 3.1. The full set of Evaluation wells was sampled (along with the other wells) to meet two objectives:

- The results would represent the first comprehensive post-closure analytical data set for ground water (i.e., all Site wells scheduled for analytical sampling would be represented); and
- Sampling all Evaluation wells together effectively resets their schedules so that in the future they will all be sampled together, in the same quarter of the same year.

3.3 Description of Current Ground Water at the RFS

This section presents a summary evaluation of ground water quality and flow at the RFS during 2006. Ground water quality is addressed first, followed by interpretations of ground water flow. Included in the discussion of water quality are descriptions of the behavior of and any notable activities at the ground water treatment systems during 2006.

3.3.1 Trend Plots

Numerous statistical trend plots were constructed using analytical data collected from Sentinel wells as a part of this report and for the report on the second quarter (DOE 2006g). These are presented in Appendix B.3. Plots were also constructed for locations associated with the SPPTS, and are discussed separately in Section 3.3.2.3.

The Sanitas™ software package (version 8.6; NIC 2005) was used for statistical calculations, including the construction of trend plots. (This is noted for the purpose of completeness only; this report does not make any software recommendations.) For simplicity, because the fundamental objective of Sentinel wells is to monitor plume edges and ahead of plumes, and

because no interwell statistics were planned (only intrawell assessment of the trend of an analyte over time at each given well), all wells were assigned downgradient positions.

Trends were calculated and plotted using the S-K statistical method, as recommended for Rocky Flats ground water data (K-H 2004e) and in accordance with the IMP (DOE 2006c). Trends were only plotted for selected VOCs, nitrate, and U. Of the VOCs, those analytes represented by numerous detections above the RFCA action level were included in trend calculations. For U, isotopic data from a given date at a given well were converted to mass and then summed to provide the “total” U concentration.

There were many instances in the database of multiple U results on the same date at the same well (representing any or all of the following: isotopic analysis providing results in activity units, isotopic analysis providing results in mass units, total U analysis via a metals analytical method, total U via a total U analytical method, filtered sample, unfiltered sample). Before trends were calculated, these were winnowed to a single result on each given date. Factors that were evaluated in selecting the result for statistical use included:

- Filtration status;
- Validation qualifier(s);
- Lab qualifier(s); and
- Other U results from the well.

Because most samples were filtered, where both sample results were provided the filtered result was preferred for reasons of consistency. Similarly, where two very different results were presented, that most similar to other results from the well was retained. When the results were assigned different lab or validation qualifiers, that with the qualifier indicating it to be most representative was selected. (For example, if one result was assigned a lab qualifier and the other had no qualifier, and the validation on both was the same, the unqualified result was retained.) For the remaining instances of multiple results, the higher value was typically selected unless professional judgment did not support this decision.

Data from original wells were grouped with those from replacement wells to form a data set on which the statistics were based. This may prove to be inappropriate. As more data are collected, the populations from original and replacement wells may prove to be discontinuous, suggesting data from the original well(s) be removed from statistical assessments of the ground water data. This determination will be made as the post-closure data set gets large enough to allow such an evaluation. Therefore, it should be stressed that trends calculated for these wells may be misleading in that they may be strongly affected by well replacement, as opposed to reflecting only ground water geochemistry and hydrology.

The IMP (DOE 2006c) instructs that nondetects be replaced by zeroes when performing statistical assessments. However, to calculate trends the data cannot contain zeroes. Therefore, instead of zeroes, nondetects were replaced with a value of 0.001. The Sanitas™ program generally incorporates nondetects in calculations at one-half the listed value, which in this case would be 0.0005. Likewise, the program cannot perform the necessary statistical calculations if negative numbers are included in the results, as is occasionally the case with results for U isotopes and other radionuclides. Following conversion of isotopic activities to masses and

summation, the resulting sum was on a few occasions negative; these results were also replaced with 0.001.

No data replacements were made for some questionable results that warrant additional inspection prior to any conclusions being made. In particular, this applies to results for methylene chloride that are B-qualified, signifying the presence of blank contamination. As this compound is a commonly used laboratory solvent, B-qualified results should be carefully reviewed alongside corresponding detection limits, concentrations in the blanks, and other relevant data before basing any decisions on them. However, as shown by the S-K trend plots none of the methylene chloride trends are increasing with a 95 percent level of significance.

Table 3–5 summarizes the results of the S-K trend plots. Refer to Appendix B.3 for the plots and associated summary information, and Figure 3–1 for well locations. Significant trends are discussed later in this section in the context of their respective ground water contaminant plumes.

Additional data will be collected to further refine the trend plots. Given that the bulk of the data at all locations listed was collected before the Site was closed and in many cases is from wells that have since been replaced, some change in slope is to be expected as the hydrologic and geochemical systems stabilize. For a cross-walk of original and replacement wells, refer to the IMP (DOE 2006c: Appendix B, Table B-4).

3.3.2 Ground Water Plumes with Treatment Systems

Ground water quality data were obtained for all monitored areas in 2006. Analytical data have been published in quarterly reports issued for 2006 (DOE 2006f, 2006g, 2007d), plus Appendix B.6, and will not be duplicated here. Appendix B.3 includes the S-K trend plots that were contained within those documents and S-K trend plots for 4CQ06.

Ground water quality at the Site was largely consistent in 2006 with data reported in prior years. Ground water plumes that were identified and characterized through the decades of pre-closure ground water monitoring at the Site do not appear to have been greatly affected during 2006 by the closure of the Site. This is to be expected; 2006 was a relatively dry year, and additional time will be required for the ground water regime to equilibrate to post-closure conditions.

Although obvious, it is worth stressing that the reduction in size and density of the ground water monitoring network compared to that operating prior to Site closure does not permit the assessment of small-scale changes in plume configuration, nor in many other local-scale attributes. This is consistent with the vision and design of the closure network, which was never intended to provide the level of detail afforded by the extremely dense well network existing in past years.

This section describes the general ground water quality in various areas of interest across the Site. Descriptions of activities and conditions in 2006 at the three ground water contaminant plume treatment systems are also provided. Refer to previously published quarterly reports (DOE 2006f, 2006g, 2007d) and Appendix B.6 for any data that may be of special interest.

Table 3–5. Summary of Seasonal Kendall Trend Calculations for Sentinel Wells

Well	General Location	Analyte	Trend	Significant at 95%?
00797	B881	U	Increasing	Yes
4087	East of PLF	U	Decreasing	No
04091	East Trenches Plume	Carbon tetrachloride	Decreasing	Yes
04091	East Trenches Plume	Methylene chloride	No slope	No
04091	East Trenches Plume	PCE	Decreasing	No
15699	MSPTS	1,1-DCE	Decreasing	No
15699	MSPTS	Chloroform	Decreasing	No
15699	MSPTS	Methylene chloride	Decreasing	Yes
15699	MSPTS	PCE	Decreasing	No
15699	MSPTS	TCE	Decreasing	No
15699	MSPTS	Vinyl chloride	No slope	No
20705	B771	Cis-1,2-DCE	Increasing	No
20705	B771	TCE	No slope	No
20705	B771	U	Increasing	Yes
23296	ETPTS	Carbon tetrachloride	Decreasing	Yes
23296	ETPTS	Chloroform	Decreasing	Yes
23296	ETPTS	Cis-1,2-DCE	Increasing	Yes
23296	ETPTS	Methylene chloride	Decreasing	Yes
23296	ETPTS	PCE	Decreasing	Yes
23296	ETPTS	TCE	Decreasing	No
37705	B371	Nitrate	Increasing	No
40305	B444	Methylene chloride	No slope	Yes
40305	B444	TCE	Decreasing	Yes
51605	North Walnut Creek	U	Increasing	Yes
70299	SPPTS	Nitrate	Decreasing	Yes
88104	B881	U	Decreasing	Yes
90299	903 Pad/Ryan's Pit Plume	Carbon tetrachloride	Decreasing	No
90299	903 Pad/Ryan's Pit Plume	PCE	No slope	No
90299	903 Pad/Ryan's Pit Plume	TCE	Decreasing	Yes
90399	903 Pad/Ryan's Pit Plume	Carbon tetrachloride	Decreasing	No
90399	903 Pad/Ryan's Pit Plume	Methylene chloride	No slope	No
95099	ETPTS	Carbon tetrachloride	No slope	No
95099	ETPTS	Chloroform	No slope	Yes
95099	ETPTS	Methylene chloride	No slope	Yes
95199	ETPTS	Cis-1,2-DCE	Decreasing	No
95199	ETPTS	Methylene chloride	No slope	Yes
99305	B991	1,1-DCE	No slope	No
99305	B991	Cis-1,2-DCE	Increasing	No
99305	B991	PCE	Increasing	No
99305	B991	Vinyl chloride	No slope	No
99305	B991	U	Increasing	No
99405	B991	PCE	No slope	No
99405	B991	TCE	No slope	No
99405	B991	U	Decreasing	No
B206989	East of PLF	Carbon tetrachloride	No slope	No
B206989	East of PLF	Chloroform	No slope	No

Notes:

Trends are listed if there is an 80% statistical significance; any decisions that may be made would be based on trends having a 95% significance.

Bold entries designate those trends having a 95% significance.

3.3.2.1 Mound Plume and Treatment System

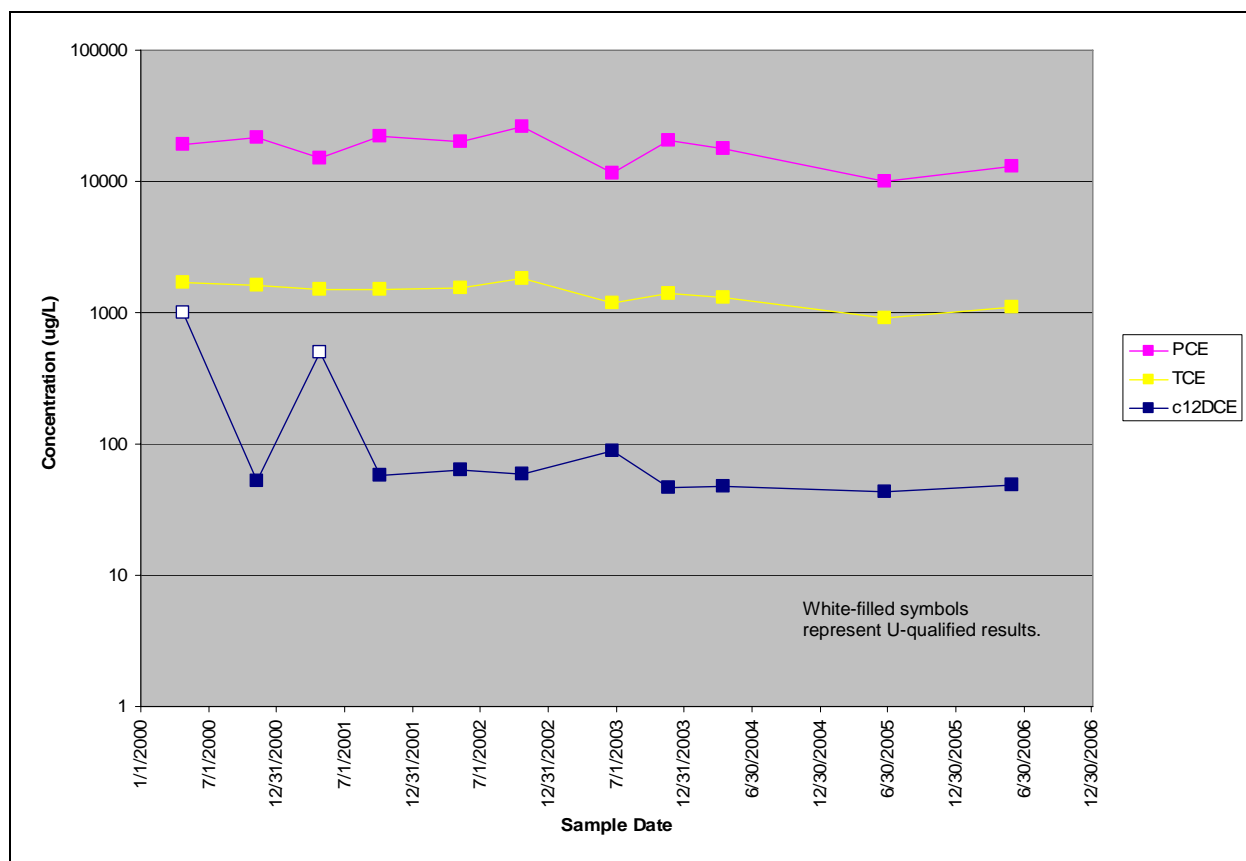
The Mound Plume (a.k.a. Mound Site Plume) is located north of the former 903 Pad. The source of the plume is a former drum storage area (“the Mound”) that was in use in the 1950s. Some of the drums leaked, creating a ground water contaminant plume extending northward toward South Walnut Creek. The drums were removed in 1970, and contaminated soils were removed in 1997. The following paragraphs describe the plume and treatment system installed to address the ground water contamination.

Mound Plume

The Mound Plume is characterized by elevated concentrations of tetrachloroethene (PCE) and trichloroethene (TCE). The source area is very near Oil Burn Pit (OBP) #2, source of another VOC plume, which is discussed separately below.

The ground water sample collected from Evaluation well 00897 in 2006 contained concentrations of VOCs that were generally consistent with previous data. These results continue to support a possible (and modest) decrease in concentrations, as suggested in the 2005 Annual Report (DOE 2006e). However, the aerobic conditions in ground water here and elsewhere across the Site hamper more rapid biodegradation of the parent products (PCE and TCE). Figure 3–2 displays concentrations of PCE, TCE, and cis-1,2- dichloroethene (DCE) in ground water samples from well 00897. PCE in this well has ranged 11,500 µg/L to 26,000 µg/L from 2000 through 2004; in a sample collected in May 2006 it was reported at 13,000 µg/L. TCE has ranged from 1,170 µg/L to 1,800 µg/L over the same period, and in the May 2006 sample it was reported at 1,100 µg/L. Cis-1,2-DCE was reported at a concentration of 49 µg/L (estimated) in May 2006, from a range of 47.2–89.1 µg/L (estimated) over the same period. Additional data will be required to confirm any decreasing trend, but such a long-term pattern is expected following the source excavation in 1997.

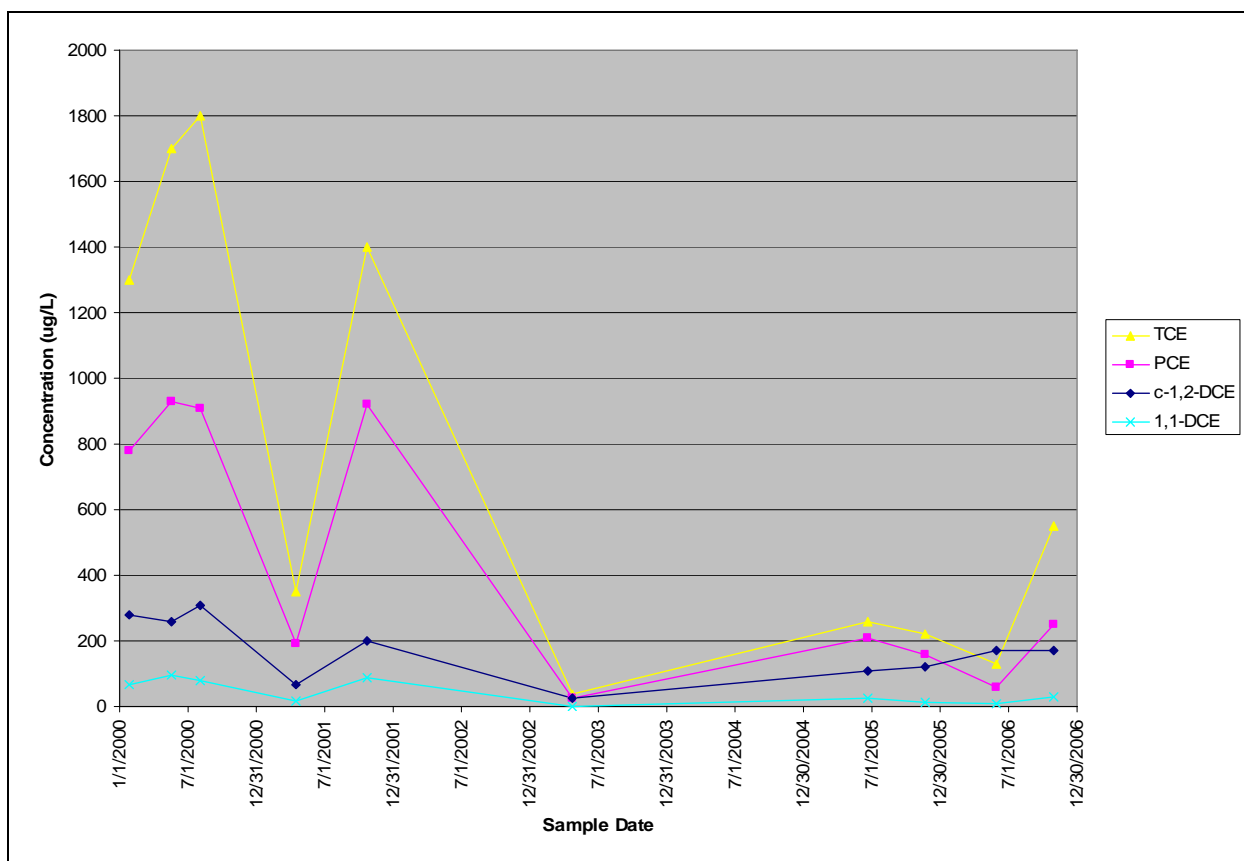
Downgradient of this source-area well, the plume is monitored by Sentinel well 15699 and Decision Document well 3586, but the Mound Site Plume Treatment System (MSPTS) intercept trench collects Mound plume ground water and diverts it to the treatment cells upgradient of these wells. Ground water at wells 15699 and 3586 is therefore physically separated from the main body of the plume. VOCs were detected in ground water samples from well 15699 during 2006, and primarily included PCE and its degradation byproducts, TCE, cis-1,2-DCE, and 1,1-DCE, as well as low concentrations of vinyl chloride. Well 3586 reported only very low concentrations of 1,1-dichloroethane (DCA) and cis- and trans-1,2-DCE.



Notes: cis-1,2-DCE = cis-1,2-DCE. RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): PCE, 5; TCE, 5; cis-1,2-DCE, 70. In addition to the nondetects (U-qualified results), several other results were qualified (D, DB, J, DJ), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–2. Concentrations of PCE, TCE, and cis-1,2-DCE in Well 00897

Figure 3–3 displays concentrations of PCE, TCE, cis-1,2-DCE, and 1,1-DCE in samples from well 15699. (Refer to DOE 2006f, 2006g, 2007d, and Appendix B.6 for additional analytical data.) Clearly evident in this figure is the strong correlation among concentrations of these constituents, with the relative concentration of each mirroring its position in the degradation pathway of PCE. With successive dechlorination, PCE is transformed to TCE and then to cis-1,2-DCE and 1,1-DCE (K-H 2004a). With more active biodegradation of chlorinated solvents in the Mound Plume, one would expect to see a relative increase of daughter products and a corresponding decrease in concentrations of parent products. Instead, the lock-step pattern of these constituent concentrations indicates a low rate of biodegradation over the time period displayed. This is consistent with conclusions made in previous studies of biodegradation in this area (e.g., K-H 2004a) and as noted in the discussion above regarding well 00897.



Notes: RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): PCE, 5; TCE, 5; cis-1,2-DCE, 70; and 1,1-DCE, 7. Several results are qualified (J, D, or in one case, U), but are not shown differently for the sake of simplicity.

Figure 3–3. VOCs in Samples from Sentinel Well 15699

S-K trend plots for well 15699 (see Appendix B.3, as well as Section 3.3.1 and Table 3–5) show a statistically significant (95 percent) decreasing trend for methylene chloride in well 15699. However, this is an artificial conclusion, as all data reported since 2001 have been nondetects.

Mound Site Plume Treatment System

The MSPTS was the first ground water intercept/treatment system to incorporate zero-valent iron (ZVI) installed at the Site, and is actually among the first of its type in the world. This work was completed in 1998.

Routine maintenance activities performed at the MSPTS in 2006 included weekly raking of the media and inspection of influent and effluent flow conditions, and calibration of the flow monitoring instrumentation. Raking is performed to break up the crust that develops on the surface of the media. In July and August of 2006, due to the development of a much thicker oxidized crust on the surface of the ZVI, reduction in media permeability, and increasing concentrations of VOCs in system effluent (DOE 2006e), the ZVI media was replaced.

Media replacement was made difficult by the fact that the media in the west (upgradient) cell had become bound into a solid mass by the iron oxyhydroxides and other precipitates that had formed. Heavy equipment was required to break up and remove the spent media, and the process

took several weeks; Figure 3–4 includes photographs showing the replacement activity in progress.

While the heavy equipment was present, additional automated instrumentation was installed at the MSPTS to support maintenance and operation of this system. Depth to water in the intercept trench and both cells is now measured, as are the influent flow rate and line pressure and the volume of water treated. Instruments are controlled and all plumbing is now routed through a small vault situated between the two treatment cells. (A similar instrumentation vault was installed earlier at the East Trenches Plume Treatment System [ETPTS], as discussed below.) Data from these instruments are accessed via the internet and are used to monitor and enhance the performance of the system.

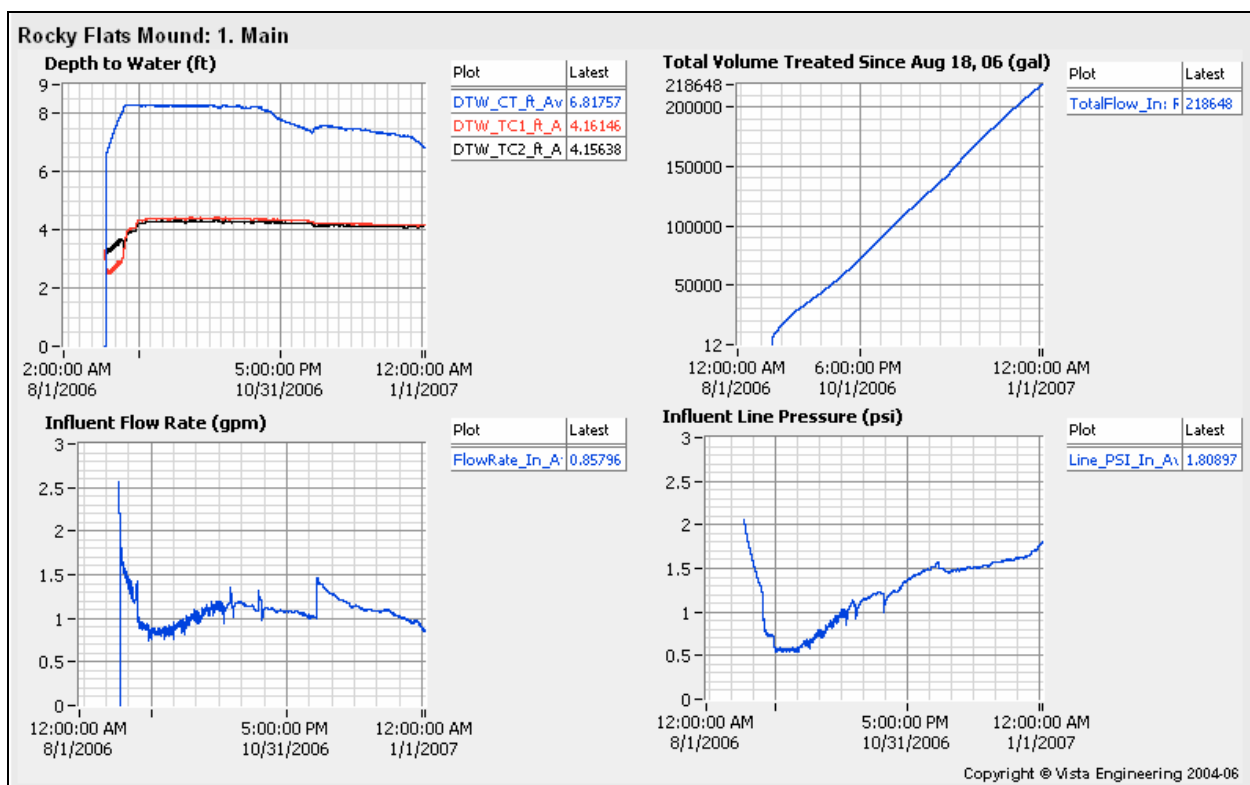
Figure 3–5 summarizes data from this instrumentation since it was activated on August 18, 2006, through the end of 2006.

In addition to these instrumentation upgrades, the plumbing at the treatment cells was upgraded to afford an upflow condition within each cell (i.e., such that the influent water would move upward through the media and exit at the top of the cell, rather than moving downward through the media). Flow direction was not changed to upflow, but this configuration may be used in the future if there are indications that it would extend the life of the media and/or enhance treatment of the water.



Left: Using a backhoe to break up the solidified ZVI media. Right: Once broken up, the media had to be hand-loaded into the backhoe bucket; additional safety requirements included harness and man-lift, ventilation hoses, and personal protective equipment.

Figure 3–4. Media Replacement at the MSPTS



Notes: Upper left graph: DTW = depth to water in feet below measuring point. CT = collection (intercept) trench, TC1 and TC2 = treatment cells 1 (west) and 2 (east), respectively. Upper right graph: gal = gallons. Lower left graph: gpm = gallons per minute. Lower right graph: psi = pounds per square inch measured in the line feeding cell 1.

Figure 3-5. Data Display From Automated Instrumentation Installed at the MSPTS

Prior to the media replacement and installation of the instrumentation vault, the MSPTS exfiltration gallery was replaced. The original exfiltration line had been buried during the final Site regrading activities and construction of FC-4 in this area, and water was not discharging properly. The old line was removed and replaced with a new line that discharges to a gravel bed near FC-4; cleanout ports were also installed to allow the line to be maintained.

Flow rates through the system have remained well above pre-2005 levels following the addition of the flow through the corridor remaining after the removal of the 72-inch storm drain that was present along the west side of the MSPTS. (For additional background, see the 2005 Annual Report, DOE 2006e.) The total volume of water treated by the MSPTS during 2006 was approximately 430,000 gallons. This is about 20 percent less than that reported in 2005 (506,000 gallons), but is still approximately five times the volumes treated in 2003 and 2004 (82,000 and 86,000 gallons, respectively). The decrease relative to 2005 was anticipated and discussed in the 2005 Annual Report (DOE 2006e), and is likely due to the combined effects of the loss of Site contributions (e.g., dust suppression and leaking water supply) and the fact that 2006 was a dry year. It should also be noted that the MSPTS was shut down during the media replacement activity in July and August; during that period, water was stored within the intercept trench but some subsurface leakage would be expected.

Some VOCs were detected in MSPTS treated effluent in 2005 (DOE 2006e) and 2006, in part leading to the replacement of the media as discussed above. The main constituents detected in the effluent were PCE, TCE, and cis-1,2-DCE, results for which are summarized in Table 3-6.

Concentrations were increasing until the media was replaced in August, which restored water treatment. Refer to the quarterly reports (DOE 2006f, 2006g, 2007d) and Appendix B.6 for additional water quality data from the MSPTS.

Table 3–6. Selected VOC Data from MSPTS Influent and Effluent

Sample Date	Analyte	MSPTS Influent	MSPTS Effluent	Sample Date	Analyte	MSPTS Influent	MSPTS Effluent
1/27/2000	DCE	57	1	4/25/2002	DCE	24	1.8
	PCE	120	0.1(J)		PCE	41	1(U)
	TCE	150	1(U)		TCE	76	1(U)
2/8/2000	DCE	59	2	10/21/2002	DCE	11.3	1(U)
	PCE	96	1(U)		PCE	33.6	1(U)
	TCE	140	1(U)		TCE	46.8	1(U)
3/7/2000*	DCE	62	2	4/17/2003	DCE	23	4.4
	PCE	100	1(U)		PCE	31	0.38(J)
	TCE	160	1(U)		TCE	38	0.31(J)
4/26/2000	DCE	61	4	12/1/2003	DCE	9	1
	PCE	110	1(U)		PCE	22.6	1(U)
	TCE	140	1(U)		TCE	31.4	1(U)
5/15/2000	DCE	42(D)	3	6/9/2004	DCE	6.98	1(U)
	PCE	68(D)	1(U)		PCE	21.5	1(U)
	TCE	87(D)	1(U)		TCE	28.3	1(U)
6/14/2000	DCE	42	1	10/20/2004	DCE	5.59	0.83(J)
	PCE	130	1(U)		PCE	25.7	0.72(J)
	TCE	150	1(U)		TCE	29.4	2.74
7/19/2000	DCE	42	2	6/21/2005	DCE	3.93	2.04
	PCE	64	1(U)		PCE	29.1	1.66
	TCE	79	1(U)		TCE	34.9	1.28
8/16/2000	DCE	39	1(J)	11/18/2005	DCE	20	6.3
	PCE	100	1(U)		PCE	81	4.5
	TCE	140	1(U)		TCE	90	1.6
9/13/2000	DCE	32.1	0.74	4/25/2006	DCE	920	390
	PCE	65.3	0.5(U)		PCE	150	5.7
	TCE	99.9	0.5(U)		TCE	150	7.6
10/25/2000	DCE	37.3	0.69	6/5/2006	DCE	2040(D)	793(D)
	PCE	68.7	0.33(J)		PCE	125(D)	3
	TCE	104	0.5(U)		TCE	158(D)	4.6
4/19/2001	DCE	38(D)	3	10/5/2006	DCE	6580(D)	0.78(J)
	PCE	44(D)	1(U)		PCE	87.2	1(U)
	TCE	76(D)	1(U)		TCE	93.7	1(U)
10/25/2001	DCE	23	0.9(J)				
	PCE	50	1(U)				
	TCE	74	1(U)				

Results are in µg/L. DCE = cis-1,2-dichloroethene; PCE = tetrachloroethene; TCE = trichloroethene; RFCA action levels in µg/L for these constituents are 70, 5, and 5 respectively (CDPHE, DOE, and EPA 2003). Lab qualifiers: D = analysis was performed at a dilution; J = result is estimated below the sample quantitation limit; U = analyte not detected. * Effluent sample was collected the next day, March 8 2000. Formal sampling location names are Mound R1-0 (influent) and Mound R2-E (effluent).

Data for samples of MSPTS influent (Table 3–6) show the influence of the modifications made upgradient of the system. As reported in the 2005 Annual Report (DOE 2006e) and mentioned

above, the preferential pathway formed by the corridor that once hosted a 72-inch storm drain was tied into the MSPTS ground water intercept trench. This pathway now transports water from the OBP #2 source area to the MSPTS. The source area was remediated prior to Site closure and Hydrogen Release Compound[®] (HRC) was added to the backfill, enhancing the natural degradation of residual VOCs. This is the most likely reason for the sharp increase in the daughter product, cis-1,2-DCE, and the smaller increases in parent products such as PCE, TCE, and other VOCs (see DOE 2006f, 2006g, 2007d, and Appendix B.6) in MSPTS influent.

Two grab samples were collected in 2006 (one each in May and October) at the performance monitoring location for the MSPTS, surface water station GS10. As in 2005, results include detections of VOCs, but none exceed the corresponding surface water surface water action levels. More importantly, concentrations appear to be decreasing since the MSPTS media was replaced in August. VOCs detected in the May sample include 1,1-DCA (8.5 µg/L), cis-1,2-DCE (39 µg/L), and TCE (0.47 µg/L, J-qualified, estimated). VOCs detected in the October sample include 1,1-DCA (1.8 µg/L) and cis-1,2-DCE (0.19 µg/L, J-qualified, estimated). Collection of samples for the analysis of VOCs at this location began in 2005. As additional data are available, it will be possible to calculate trends of any VOCs that may be consistently detected at GS10.

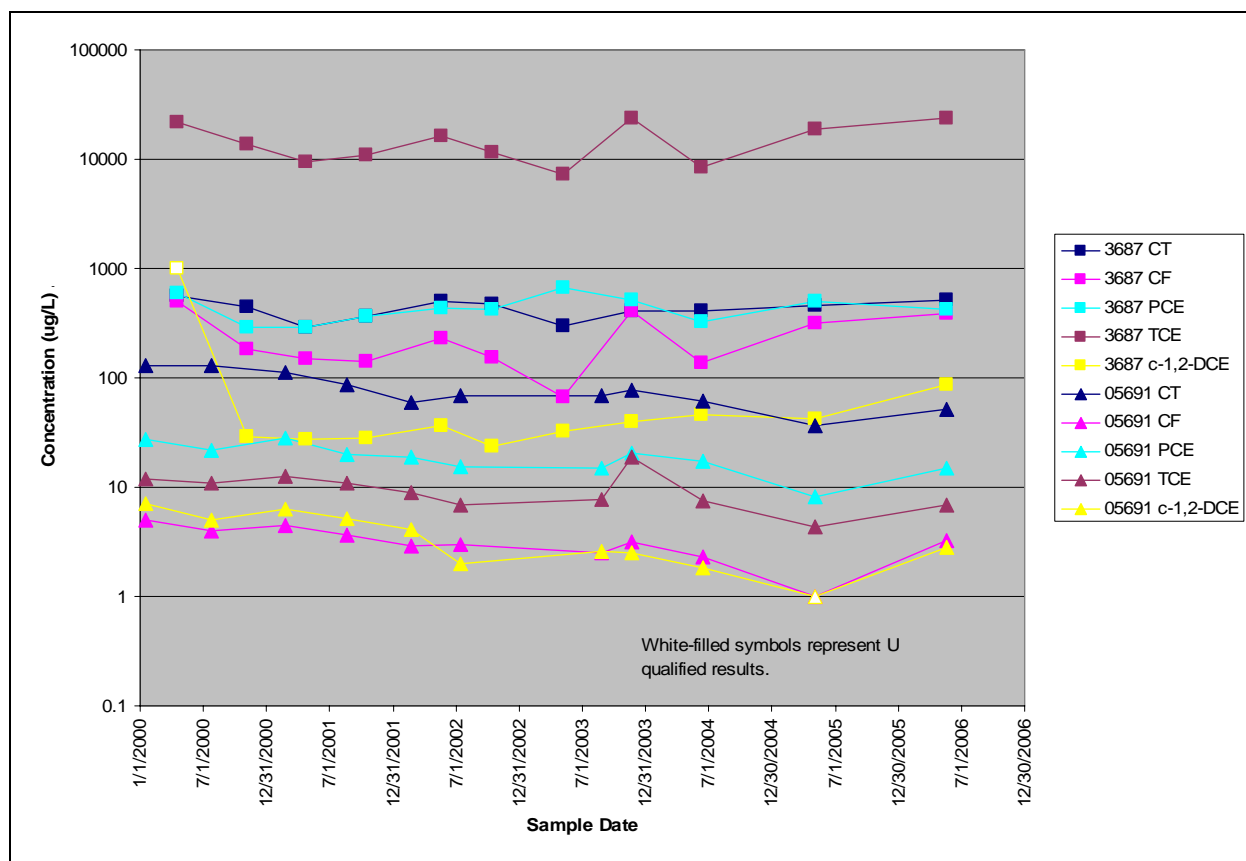
3.3.2.2 East Trenches Plume and Treatment System

The East Trenches Plume is an area of contamination named after several disposal trenches that contribute VOCs to ground water. These trenches are located on the pediment south of South Walnut Creek, in former OU 2. The source of this plume is Trenches T-3 and T-4, which were remediated in 1996. In addition, a portion of the 903 Pad Plume flows toward the northeast and joins the East Trenches Plume. The following paragraphs describe the plume and treatment system installed to address this contamination.

East Trenches Plume

Evaluation wells 3687 and 05691 monitor the source areas of the East Trenches Plume, Trenches T-3 and T-4, respectively. More distal portions of the plume are monitored by Evaluation well 03991 and Sentinel well 04091 to the east-northeast, and Area of Concern (AOC) well 00997 at the mouth of Pond B-5 in the South Walnut Creek drainage. Sentinel wells 95099, 95199, 95299, 23296, and TH046991 monitor the ETPTS, which was installed in 1999 to collect and treat contaminated ground water of the East Trenches Plume as it migrates toward the B-Ponds and South Walnut Creek.

Source-area Evaluation wells 3687 and 05691 produce samples with elevated concentrations of VOCs of the PCE and carbon tetrachloride families. The VOC present in the highest concentrations in ground water samples from well 3687 is TCE, while samples from 05691 are highest in carbon tetrachloride. Figure 3–6 provides a summary display of the most prevalent VOCs in these two wells, using a logarithmic concentration scale to better illustrate results for lower-concentration constituents.



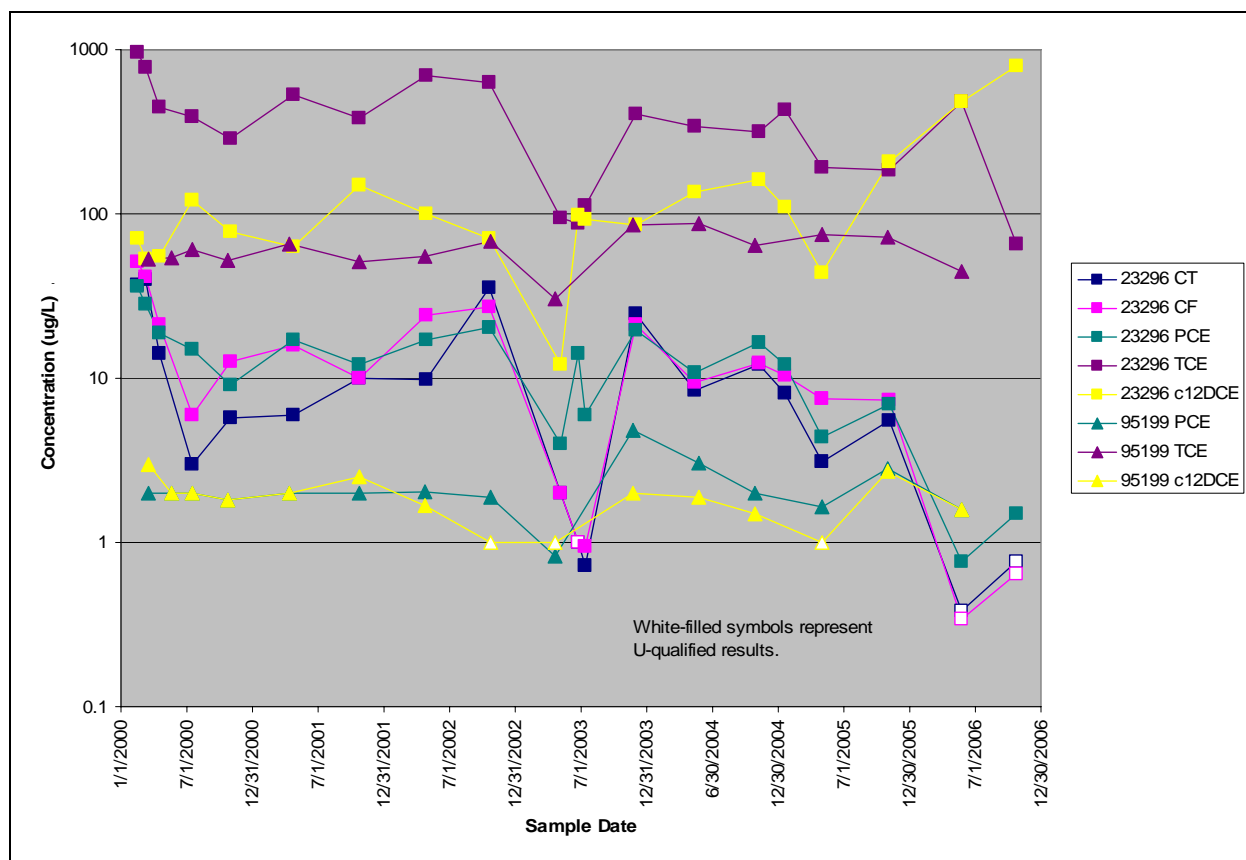
Notes: CT = carbon tetrachloride; CF = chloroform; c-1,2-DCE = cis-1,2-DCE. RFCA surface water action levels for these constituents (ug/L; CDPHE, DOE, and EPA 2003): CT, 5; CF, 5.7; cis-1,2-DCE, 70. In addition to the nondetects (U-qualified results), several other results were qualified (D, E, J), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–6. Primary VOCs in Samples from East Trenches Plume Source-Area Evaluation Wells 3687 and 05691

As indicated by Figure 3–6, concentrations of VOCs in samples from well 3687 do not appear to be changing appreciably. Concentrations in well 05691 may be exhibiting a modest decrease, although the sample collected in 2006 shows several VOCs at higher concentrations than in one or more prior samples. Apparent decreases or increases in concentrations will be evaluated as more post-closure data are available.

Wells monitoring the downgradient portion and edges of the East Trenches Plume include Sentinel wells 23296, 95099, 95199, 95299, and TH046992. With the exception of wells 95099 and TH046992, each is physically separated from the main body of the East Trenches Plume by the ETPTS ground water intercept trench.

Analytical data for these wells in 2006 were generally consistent with those from recent years. (Well TH046992 is represented by few data, as it was added to the network in 2005.) Of these wells, samples from 23296 contain the highest concentrations of VOCs. Figure 3–7 displays VOCs most commonly detected in these wells at concentrations exceeding the corresponding RFCA action level. Refer to Appendix B.3 for S-K trend plots.



Notes: CT = carbon tetrachloride; CF = chloroform; c12DCE = cis-1,2-DCE. RFCA surface water action levels for these constituents ($\mu\text{g/L}$; CDPHE, DOE, and EPA 2003): CT, 5; CF, 5.7; cis-1,2-DCE, 70. In addition to the nondetects (U-qualified results), several other results were qualified (D, J), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–7. Most Commonly Detected VOCs in Sentinel Wells Downgradient of the ETPTS

S-K trend plots (Appendix B.3, and summarized above in Section 3.3.1 and Table 3–5) indicate 95 percent significant trends for several constituents monitored in the East Trenches Plume wells. Well 23296 is represented by significant trends for carbon tetrachloride (decreasing), chloroform (decreasing), cis-1,2-DCE (increasing), methylene chloride (decreasing), PCE (decreasing), and TCE (decreasing). These trends suggest the source removal actions are affecting concentrations of VOCs as desired; the increasing trend in cis-1,2-DCE suggests ongoing degradation of parent compounds.

Wells 95099 and 95199 also are represented by significant trends, although in each case the trend is no slope: chloroform and methylene chloride at well 95099, and methylene chloride at well 95199. However, these trends are artificial: all of the data since 2001 for methylene chloride have been nondetects, and almost all data for chloroform are nondetects, with the exceptions being J-qualified (estimates) and the highest such detection estimated at $0.3 \mu\text{g/L}$.

In the distal portions of the plume, well 04091 shows a statistically-significant (95 percent significance) decreasing trend in carbon tetrachloride concentrations (Table 3–5).

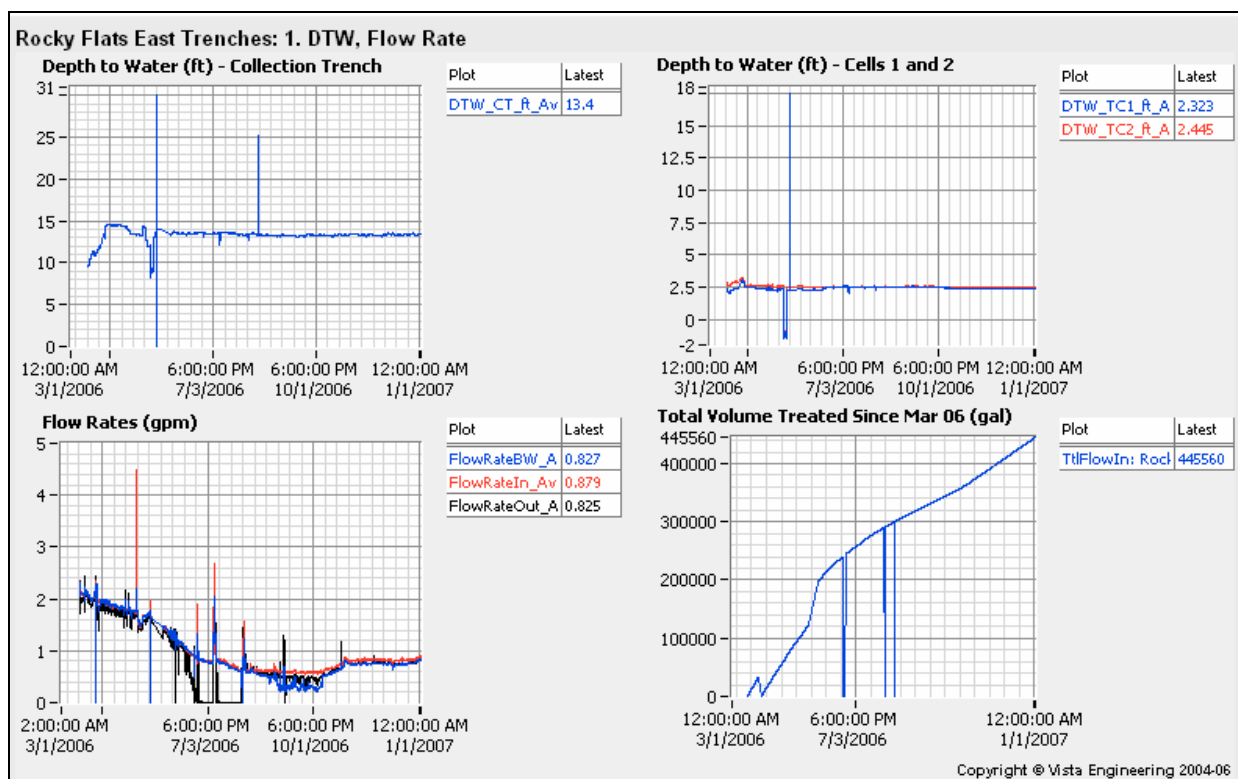
East Trenches Plume Treatment System

The ETPTS was installed in 1999. Its design is very similar to that of the MSPTS. However, the intercept trench for the ETPTS is 1,200 feet long, compared to the 220 foot long MSPTS trench. The longer trench is required to intercept the broader East Trenches Plume as it flows toward South Walnut Creek and the B-Ponds.

The ETPTS treated approximately 675,000 gallons of water in 2006. This is significantly less than in recent years; it is about 38 percent of the total flow in 2005 (1.8 million gallons). In 2003, 2.1 million gallons were treated, and in 2004, 1.5 million gallons were treated. This decrease in flow suggests a large combined effect from the dry year and loss of artificial contributions; indeed, adjacent Ponds B-1, B-2, B-3, and B-4 were dry or nearly so for much of the spring, summer, and fall of 2006.

For the first several years following its installation, the ETPTS functioned well. However, frequent intensive maintenance (including media replacement) was required beginning in 2003. The media in both cells was replaced in September–October 2003, partially replaced in both cells in May 2004, partially removed in December 2004, and completely replaced in September 2005. Other more intensive maintenance work at the ETPTS in recent years has included using heavy equipment to break up the crusted iron, flushing the media with acid to restore flow, and performing plumbing repairs and upgrades.

Routine maintenance at the ETPTS in 2006 included weekly raking of the media, inspection of influent and effluent flow conditions, and calibration of the flow monitoring instrumentation. Automated instrumentation was installed in March 2006 to enhance maintenance and operation of the system. This was reported in more detail in the 2005 Annual Report (DOE 2006e) and in the corresponding quarterly report (DOE 2006f), and those details will not be reiterated here. Briefly, the instrumentation and associated vault are similar to that installed at the MSPTS, as described above, and include measurement of water depth in the intercept trench (collection trench) and both cells, and flow rates. Figure 3–8 provides the summary display of data collected from the installation of the instrumentation vault through the end of 2006; occasional spikes and other discontinuities in the data represent periods of troubleshooting and instrumentation correction.



Notes: Upper left graph: DTW = depth to water in feet below measuring point. CT = collection (intercept) trench. Upper right graph: DTW = depth to water in feet below measuring point. TC1 and TC2 = treatment cells 1 and 2, respectively. Lower left graph: gpm = gallons per minute, BW = between cells, In = influent, Out = effluent. Lower right graph: gal = gallons.

Figure 3–8. Data Display From Automated Instrumentation Installed at the ETPTS

In addition to these instrumentation upgrades, the plumbing at the treatment cells was upgraded to afford an upflow condition within each cell (i.e., such that the influent water would move upward through the media and exit at the top of the cell, rather than moving downward through the media) and the discharge line was replaced. Flow direction was not changed to upflow, but this configuration may be used in the future if there are indications that it would extend the life of the media and/or enhance treatment of the water. Also, the discharge line was replaced because the original line did not present sufficient gradient, causing water to frequently back up into the effluent manhole.

The ETPTS treatment of ground water in 2006 was improved with respect to much of its history. The system was sampled twice: once in May, and once in October. VOCs detected in the effluent on both occasions included 1,1-DCA (1 µg/L in May, and estimated—J-qualified—0.45 µg/L in October), cis-1,2-DCE (27 µg/L and estimated 4.3 µg/L), PCE (4.1 µg/L and estimated 0.85 µg/L), and TCE (2.8 µg/L and estimated 0.18 µg/L). These recent results can be compared with earlier data in Table 3–7; refer to quarterly reports (DOE 2006f, 2006g, 2007d) and Appendix B.6 for additional data from 2006.

Table 3–7. Summary of Recent VOC Data from ETPTS Influent and Effluent

DATE	1,1-DCE		Carbon Tetrachloride		Chloroform		cis-1,2-DCE		Methylene Chloride		PCE		TCE	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1/28/04	5	1(U)	130	1(U)	71	1.1	40	9.5	5(U)	20	290	0.93(J)	2300	1.8
2/25/04	4.8(J)	1(U)	150	1(U)	71	1.4	40	10	2.7(JB)	19(B)	270	1.1	2400	2.5
3/22/04	4.8(J)	1(U)	180	1(U)	71	1	39	9.7	2.6(U)	21	270	1.2	2400	1.8
5/26/04	2.93	1(U)	216	1(U)	65.1	1(U)	28	11.5	1(U)	17	618(D)	3.38	5510(D)	6.36
6/22/04	3.2(J)	1(U)	130	1(U)	59	1(U)	29	8	6.7(JB)	14(B)	240	1.9	1900	1.8
7/29/04	3.3	1(U)	142(D)	1(U)	54.1	1(U)	29.4	7.7	2.3	14.1(U)	354(D)	1.8	1960(D)	0.69(J)
8/19/04	1.6	1(U)	68.1	1(U)	26.6	1(U)	13.3	7.4	1(U)	13.7	137(D)	1.2	774(D)	0.55(J)
10/20/04	4.21	1(U)	160	1(U)	72.9	2.56	32.6	11.3	1(U)	15.6	230(D)	2.13	1170(D)	1.91
5/12/05	5.09	1.59	131	1(U)	66	22.2	30.4	36.4	1(U)	14.6	256(D)	21.9	2280(D)	33.1
6/7/05	5.1(J)	1.1	160	1(U)	81	30	33	44	10(U)	22(B)	340	36	3300	66
11/2/05	50(U)	1.6	151	1(U)	74.8	0.73(J)	50.7	39.6	250(U)	18.2	350	1(U)	2500	4.4
5/17/06	6.1(J)	0.39(J)	170	0.23(U)	75(J)	1.9(U)	46	27	0.32(U)	32	280	4.1	2800	2.8
10/31/06	3.9(J)	0.14(U)	120(J)	0.19(U)	75(J)	0.16(U)	40(J)	4.3(J)	6.4(U)	0.32(U)	290(J)	0.85(J)	2100(J)	0.18(J)

Notes: Results are in µg/L. Parenthetical values represent data qualifiers: D = analysis was performed at a dilution; J = result is estimated; U = analyte not detected at concentration shown; B = analyte was detected in the sample and method blank. RFCA action levels in µg/L (CDPHE, DOE, and EPA 2003): 1,1-DCE, 7 µg/L; carbon tetrachloride, 5 µg/L; chloroform, 5.7 µg/L; cis-1,2-DCE, 70 µg/L; methylene chloride, 4.7 µg/L; PCE, 5 µg/L; TCE, 5 µg/L.

The performance monitoring location for the ETPTS is POM2, which is located in Pond B-4. Sampling in support of the ETPTS began at this location in 2005. Grab samples were collected from POM2 in May and November 2006. There were no validated detections of VOCs in either sample.

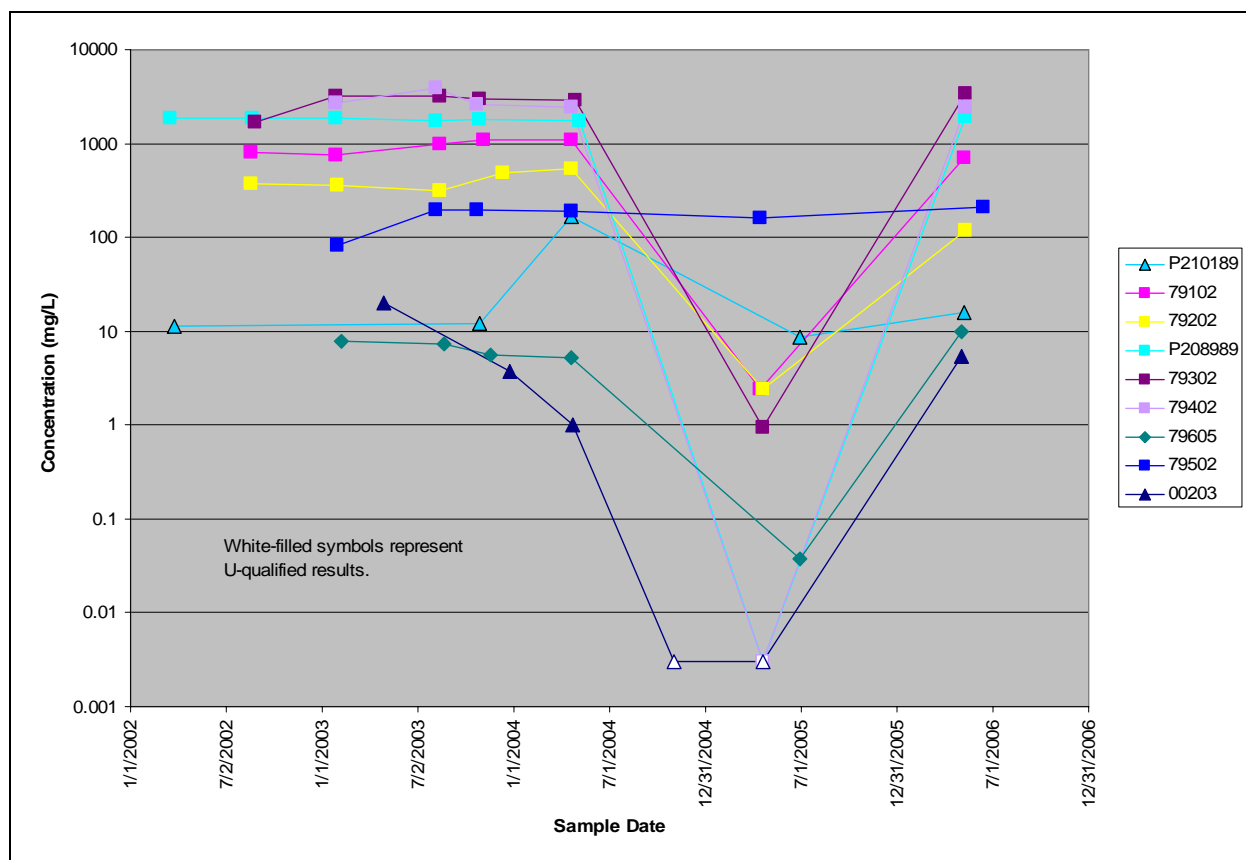
3.3.2.3 Solar Ponds Plume and Treatment System

The SPP is an area of elevated nitrate and U concentrations in ground water. (Note: The analytical data report concentrations of nitrate/nitrite as N; this is referred to herein simply as nitrate.) The former Solar Evaporation Ponds (SEPs), which were located on the pediment in the northeastern portion of the former IA, were the source of this contamination. Liquid wastes generated during production were stored in these ponds. Leaks that occurred over the years are the source of the ground water plume. The following paragraphs describe the plume, the treatment system installed to address this contamination, and work performed in 2006 on the system. Discussion of special investigations of the system is provided in Section 3.5.2.

Solar Ponds Plume

Ground water in the SEP area is contaminated with nitrate and U. The westernmost portion of this area, generally coinciding with the location of former Pond 207-C, also is contaminated with VOCs.

Concentrations of nitrate in the main body of the plume in 2006 were consistent with results prior to 2005, confirming that some of the data reported in 2005 were anomalous and not representative (see DOE 2006e). Figure 3–9 provides summary nitrate data for recent years for ground water samples from the Evaluation wells surrounding the SEPs.



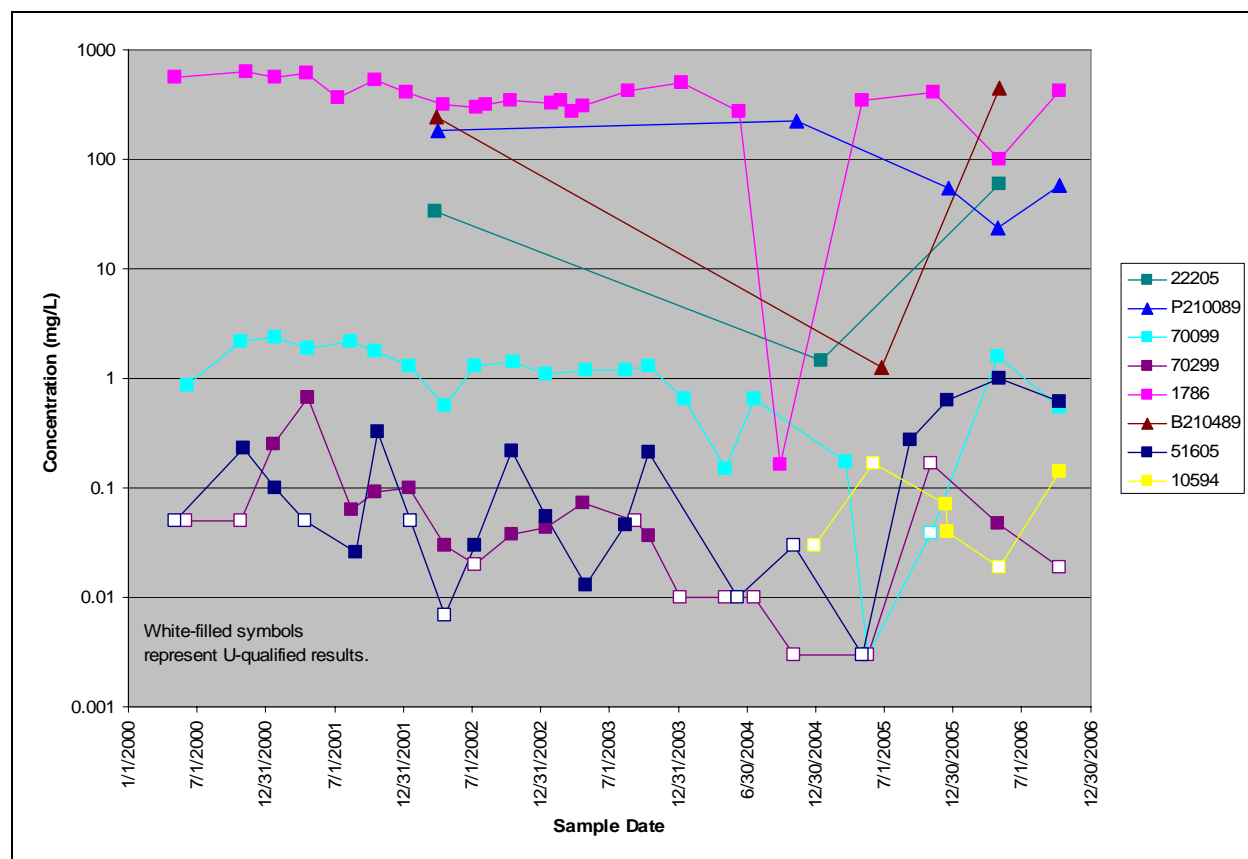
Notes: Plot for well 79605 includes data from its predecessor, P207989; and that for well 00203 includes its predecessor, 00297. Atypically-low results in 2005 represent data outliers. RFCA surface water action level for nitrate (mg/L; CDPHE, DOE, and EPA 2003) is 100 in the area of the Solar Ponds Plume. In addition to the nondetects (U-qualified results), several other results were qualified (B), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3-9. Concentrations of Nitrate in Ground Water Samples From the Solar Ponds Plume Source Area

Nitrate behaves fairly conservatively—it flows readily with ground water, and is not attenuated as much as many other constituents. In addition, the contaminant source is no longer active and vegetation has been established, which would act to reduce residual concentrations of nitrate. Although concentrations of nitrate appear relatively stable over the past several years, suggesting this contamination will not be flushed rapidly from the area, as revegetation efforts are rewarded the removal of nitrate may accelerate.

Concentrations of nitrate farther from the source area also appear relatively stable, as shown below in Figure 3-10. Worth noting are the differences between paired wells 70099 and 70299, with the former showing higher concentrations of nitrate than the latter. This is because well 70099 screens unconsolidated materials while 70299 screens the weathered bedrock, which is a less-permeable claystone. Both appear to be outside the nitrate plume, and were installed in 1999 to evaluate bypass of the SPPTS around the western end of the intercept trench. Also worth noting is the statistically-significant (95 percent) decreasing trend for nitrate at well 70299. This trend is artificial, however, as almost all results since 2003 have been nondetects. (See Appendix B.3 for the S-K trend plots, which are also summarized above in Section 3.3.1 and Table 3-5.) Figure 3-10 confirms that AOC well 10594 and Sentinel well 51605 are both

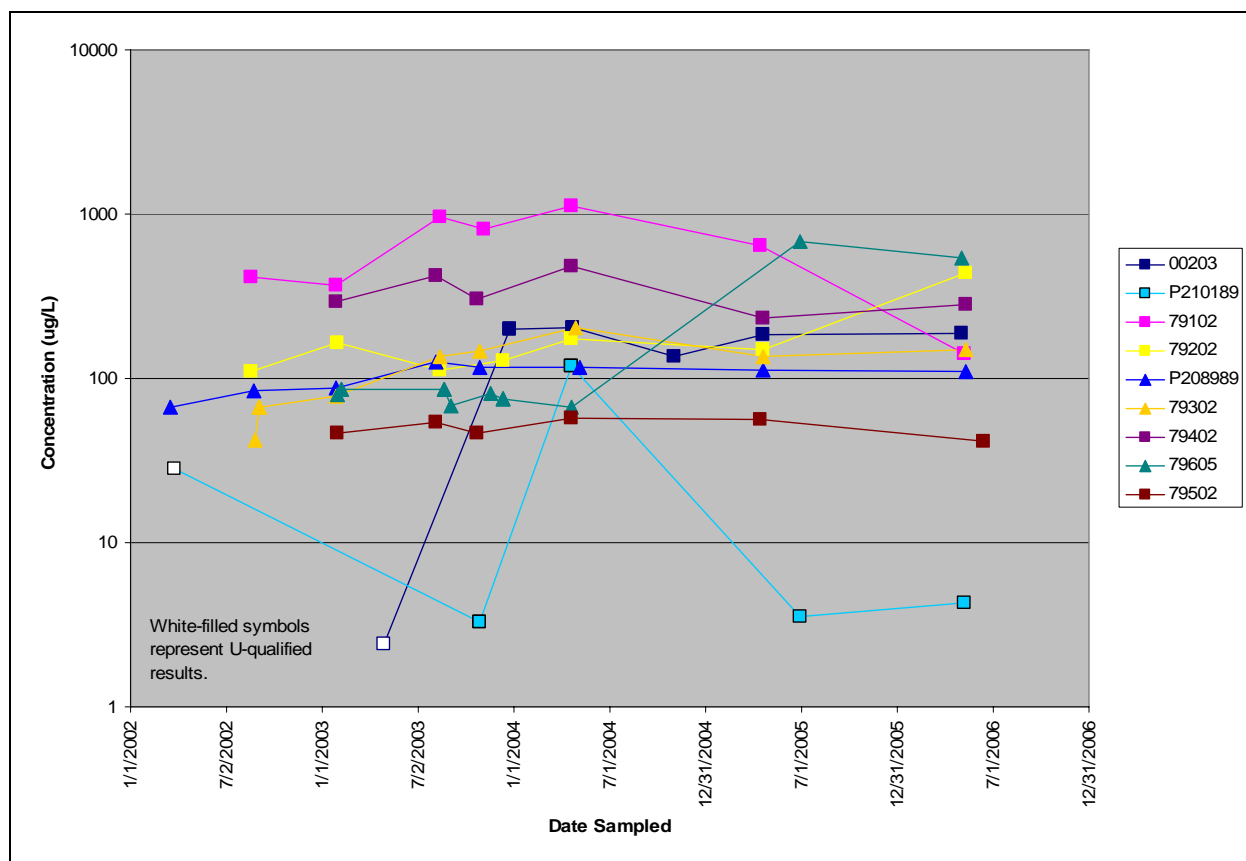
outside the nitrate plume. (Note: Data shown for well 51605 include its predecessor, 1386, which was replaced by 51605 beginning with the September 2005 data.) Wells within the plume include those closer to the source area (22205 and P210089) and those closest to the former Interceptor Trench Pump House and current SPP Discharge Gallery (1786 and B210489).



Notes: Plots for wells 22205 and 51605 include their predecessors, 22298 and 1386, respectively. Several data outliers are also obvious on the graph. RFCA surface water action level for nitrate (mg/L; CDPHE, DOE, and EPA 2003) is 100 in the area of the Solar Ponds Plume. In addition to the nondetects (U-qualified results), several other results were qualified (B, J), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–10. Concentrations of Nitrate in Ground Water Samples Downgradient of the Solar Ponds Plume Source Area

As with those for nitrate, U concentrations around the former SEPs are generally consistent with past years. Figure 3–11 provides a display of results for total U in the source area. (When preparing the plots for U, data were managed as described in Section 3.3.1.) This figure shows the concentration of U at 79605 increasing significantly between 2004 and 2005; this coincides with the replacement of original well P207989 (results from which represent the first part of the plot for 79605) and its replacement by well 79605 due to the inadvertent destruction of the former well during closure of the Site. The replacement well is about 5 feet from the original well; perhaps more importantly, it is just over 5 feet deeper, allowing it to collect more of the ground water within the weathered bedrock. This may account for the difference in U concentrations between original well P207989 and replacement well 79605.



Notes: Plots for wells 00203 and 79605 include their predecessors, 00297 and P207989, respectively. RFCA surface water action level for total U in Walnut Creek (pCi/L; CDPHE, DOE, and EPA 2003) is 10, which converts (assuming natural U) to approximately 15 µg/L. In addition to the nondetects (U-qualified results), several other results were qualified (B, E, N), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

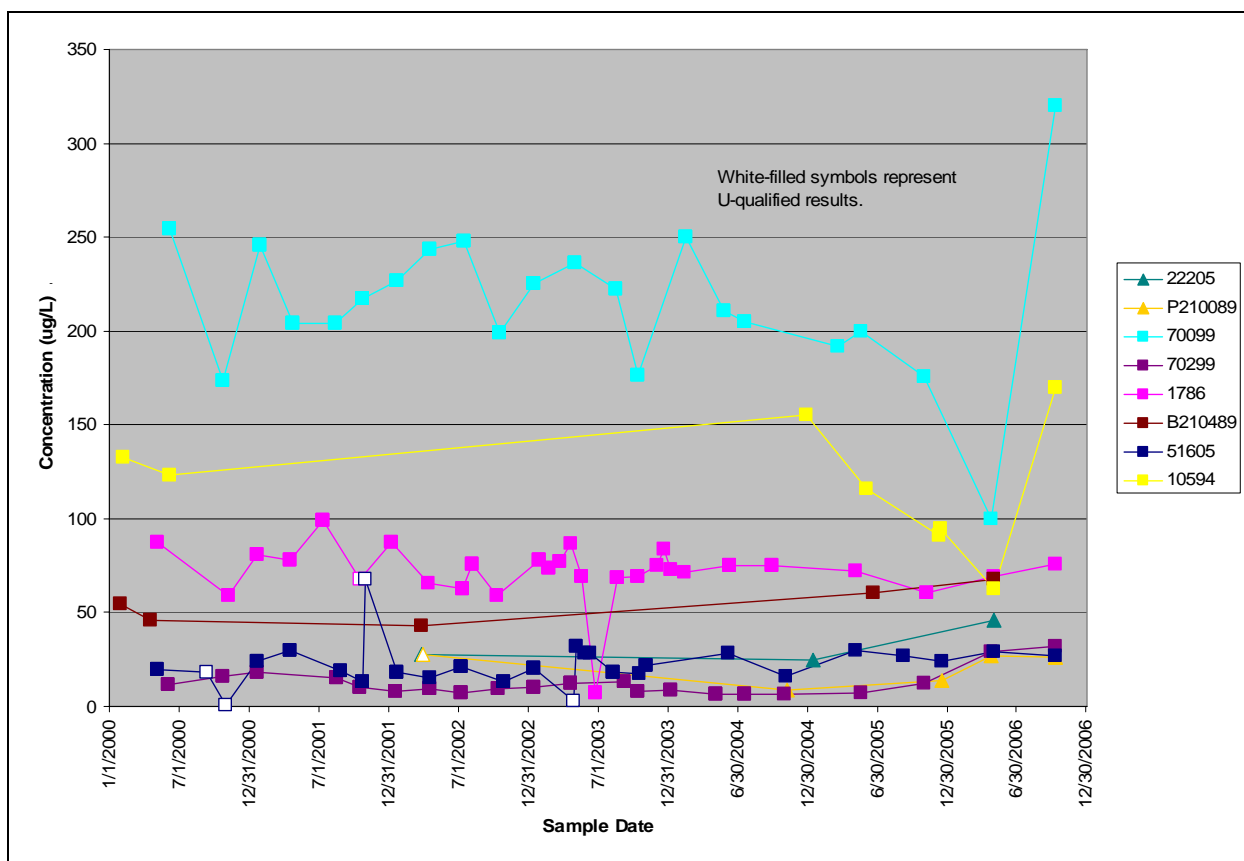
Figure 3–11. Concentrations of Uranium in Ground Water Samples From the Solar Ponds Plume Source Area

A similar mechanism may be responsible for the apparent increase in concentrations at well 00203. This well replaced shallower well 00297, which was continually dry and not suitable for long-term monitoring; the original well only produced the first sample represented on Figure 3–11.

The reason for the higher-concentration result in April 2004 at well P210189 is not known. This result may represent an anomaly or error, or it may be related to closure activities in the area. Concentrations of U after that sample have been consistently low, between 3 µg/L and 4.3 µg/L; the sample preceding the April 2004 event was reported as a nondetect at 28 µg/L.

Concentrations of U in downgradient wells are also generally consistent with previous results (Figure 3–12). The main exceptions are seen at wells 70099 and 10594. The former well, located at the northwest end of the SPPTS ground water intercept trench, is represented by two anomalous results in 2006: one, from a sample collected in April, is the lowest concentration in the period of record, while the next sample, collected in October, reported the highest concentration. The data from well 10594, located between Ponds A-1 and A-2, appear to confirm these results from well 70099; both wells appear to show a short period of declining concentrations followed by a sharp increase at the end of 2006. However, other wells in the area,

including several located between wells 70099 and 10594, do not confirm such a pattern although several display moderate increases in U through 2006. Factors that may have contributed to this pattern include the flooding of several wells (70099, 70299, and P210089) during final grading and construction of Functional Channel 3 immediately prior to closure; and the storage of untreated ground water within the SPPTS intercept trench during system repairs performed in August-September 2006. In addition, interpretation of the time series plot for well 10594 is made more difficult by the fact that this well is represented by fewer data points than most others. Because this well and well 70099 are clearly not strongly impacted by the nitrate plume and have been determined to monitor naturally occurring U (K-H 2004f), the variations in U concentrations are most likely of natural origin and/or reflect some measure of laboratory uncertainty.

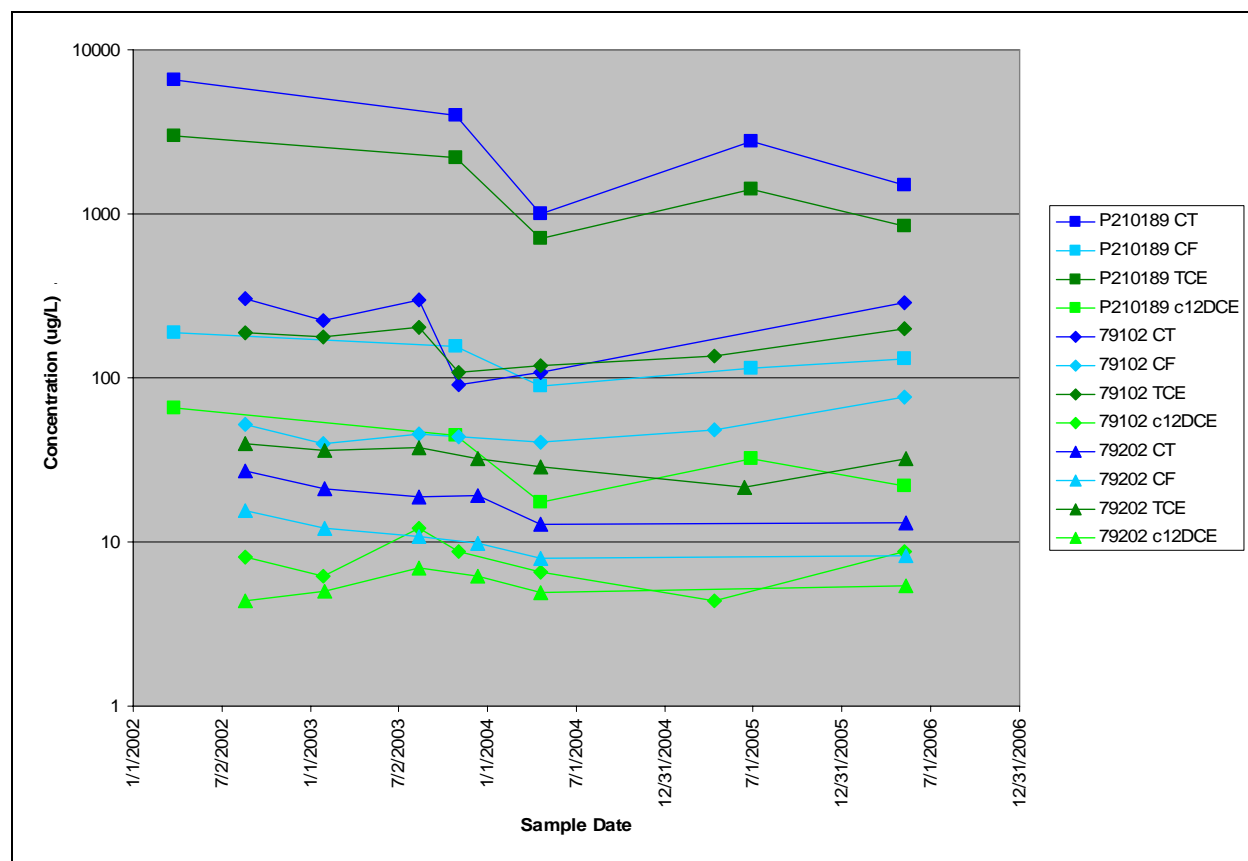


NOTES: Plots for wells 22205 and 51605 include their predecessors, 22298 and 1386, respectively. Several data outliers are also obvious on the graph. RFCA surface water action level for total U in Walnut Creek (pCi/L; CDPHE, DOE, and EPA 2003) is 10, which converts (assuming natural U) to approximately 15 $\mu\text{g/L}$. In addition to the nondetects (U-qualified results), several other results were qualified (B, J, N, *), but are not shown differently for the sake of simplicity.

Figure 3–12. Concentrations of Uranium in Ground Water Downgradient of the SPP Source Area

The S-K trend plot for well 51605 indicates a statistically-significant (95 percent) increasing trend for U at this location. Again, data for this well includes those for the original well, 1386. More importantly, concentrations of U remain well below the U threshold defined in the IMP (DOE 2006c). See Appendix B.3 for the S-K trend plots, which are also summarized above in Section 3.3.1 and Table 3–5.

The main constituents of the VOC plume in the western SEP area are carbon tetrachloride and TCE, with lesser concentrations of their daughter products (primarily chloroform and cis-1,2-DCE) and PCE. The highest concentrations of carbon tetrachloride and TCE are reported in samples from well P210189. The location of wells 79102 and 79202 were selected in part to monitor for VOCs from this plume. Concentrations of these constituents in samples collected from these wells during 2006 are generally consistent with those reported in previous years' samples. Downgradient Evaluation well 22205 reported no detections of these constituents except for low detections in 2003 of PCE (2.17 µg/L) and TCE (30.4 µg/L) that were not confirmed in subsequent samples. Downgradient Sentinel well P210089 also shows no detections of these constituents. Figure 3–13 summarizes concentrations of the major constituents of this plume. PCE is omitted because detections have been under 10 µg/L.



NOTES: CT = carbon tetrachloride, CF = chloroform, c12DCE = cis-1,2-DCE. RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): CT, 5; CF, 5.7; TCE, 5; cis-1,2-DCE, 70. In addition to the nondetects (U-qualified results), several other results were qualified (D, J), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–13. Concentrations of Primary VOCs in SEP-Area VOC Plume

As shown in Figure 3–13, concentrations of VOCs in this plume have not changed substantially over the past several years with the possible exception of decreasing concentrations in the source-area well P210189.

Solar Ponds Plume Treatment System

Like the ETPTS, the SPPTS was installed in 1999. In basic design terms, the system is very similar to the MSPTS and ETPTS, with an intercept trench (1,100 feet long) and two treatment cells. However, unlike the ETPTS and MSPTS, this system is designed to treat water with elevated concentrations of nitrate and U. As such, the treatment media in the SPPTS differs from that in the VOC-treating MSPTS and ETPTS. The treatment media in the SPPTS consists of ZVI and organic material (sawdust).

Another difference between the SPPTS and the other two systems is that the water collected in the intercept trench is pumped into the treatment cells. This is accomplished using a solar-charged, battery-powered pump system. This component of the SPPTS, together with the collection well (or “sump”) that houses the pump and is installed within the trench, was added in 2002. The system was initially designed to take advantage of gravity by situating the treatment cells near the bottom of the North Walnut Creek drainage, and routing intercepted ground water down the hill from the intercept trench to those cells. However, concerns about Preble’s meadow jumping mouse habitat in this area of North Walnut Creek caused the cells to be relocated and placed adjacent to the intercept trench. This required water to accumulate in the intercept trench to a depth of about 11 feet before it would flow into the higher-elevation treatment cells. Such a configuration was found to be unrealistic, and the pump system was installed in the fall of 2002.

Routine maintenance activities at the SPPTS were conducted throughout 2006, and include weekly inspection of the solar/battery system that powers the pump, operation of the pump, and influent and effluent flow conditions. In addition, the flow monitoring instrumentation was calibrated periodically.

System performance was satisfactory until spring 2005. Prior to that time, the system reduced nitrate and U concentrations as designed. But in spring 2005, water backed up in the system due to clogging of the gravel/ZVI media in downgradient Cell 2. The valves were reconfigured to bypass this cell. Concentrations of nitrate following this change showed no treatment. The media in Cell 2 was changed in September 2005, just prior to Site closure. U treatment resumed, but nitrate treatment was still insufficient.

In 2006, an iterative strategy for correcting the nitrate problem was developed. The valve positions were checked and found to be one issue: only two of the five valves were accessible. These were reconfigured to support series flow, resulting in a slight decrease in system effluent nitrate concentrations, but the positions of the other three valves could not be confirmed.

At the end of March 2006, heavy equipment was used to excavate and restore access to the other three valves. All valves were then reconfigured to series flow (through both cells in sequence). Field screening samples were collected frequently (2x-5x/month) to evaluate the effects of ongoing efforts to restore treatment. Nitrate concentrations in system effluent began to decrease sharply, but this decrease was inconsistent. Although effluent concentrations of nitrate continued to decrease somewhat, in the summer of 2007 it was determined that the system should be excavated to expose the treatment media and influent distribution lines.

In August 2007, heavy equipment was used to remove the approximately 12 feet of overburden (soil and wood chips) from the top of the media in the SPPTS. The last portion of the excavation

was performed by hand to avoid damaging the plumbing and media. It was found that the influent distribution gallery within nitrate-treating Cell 1 had separated from its feed line because that connection was not designed to account for settling of the sawdust/ZVI media. Additional excavation outside the cells revealed all valves to be leaking, several lines to be broken, and several penetrations through the cell walls to be unsealed, allowing water to flow freely into or out of the cells in an uncontrolled fashion. Finally, it was found that the influent line from the pump was kinked and the original line from the trench had not been capped when the pump was installed; this allowed pumped influent water to either flow into the treatment cells or cycle back into the collection well. A break in that original line also allowed pumped influent to leak into the surrounding soil rather than recirculate back into the collection well or flow to the system. The cumulative effects of these conditions would be reduced treatment effectiveness and efficiency, and reduced flow through the system due to increased system bypass. Figure 3–14 includes photographs of some of the components.



Upper left: looking down into western Cell 1 at the influent distribution gallery. Upper right: distribution gallery (gray pipes, white elbow, pipe fragment) is detached from the main influent port (the pipe in the side of the wall). The pipe extending upwards and having white tubing inside it is the west cell influent vent riser. Lower left: leaking valve feeding main influent port to Cell 1; break in T-pipe; standing water in lower left corner of photo from break in pipe and from leaking valve; kinked influent line from the pump installed in the collection well enters at 45-degree angle "Y" connection from upper right and joins the original influent line from the intercept trench (the other branch of the "Y"), allowing pumped influent to recirculate back into trench. Lower right: same location as lower left photo, but after repairs: new valves; capped line from trench prevents recirculation of water from pumped collection well back to trench; replaced cracked T-pipe; stabilized influent line. Note amount of settling indicated by original line from trench (on right), which had lined up with the valve and main influent port to Cell 1 when the system was installed in 1999, but has since settled with the intercept trench backfill. Stresses from this and other settling caused some of the problems corrected in 2006.

Figure 3–14. Photographs from SPPTS Investigation and Repair

Plumbing components were repaired or replaced as follows:

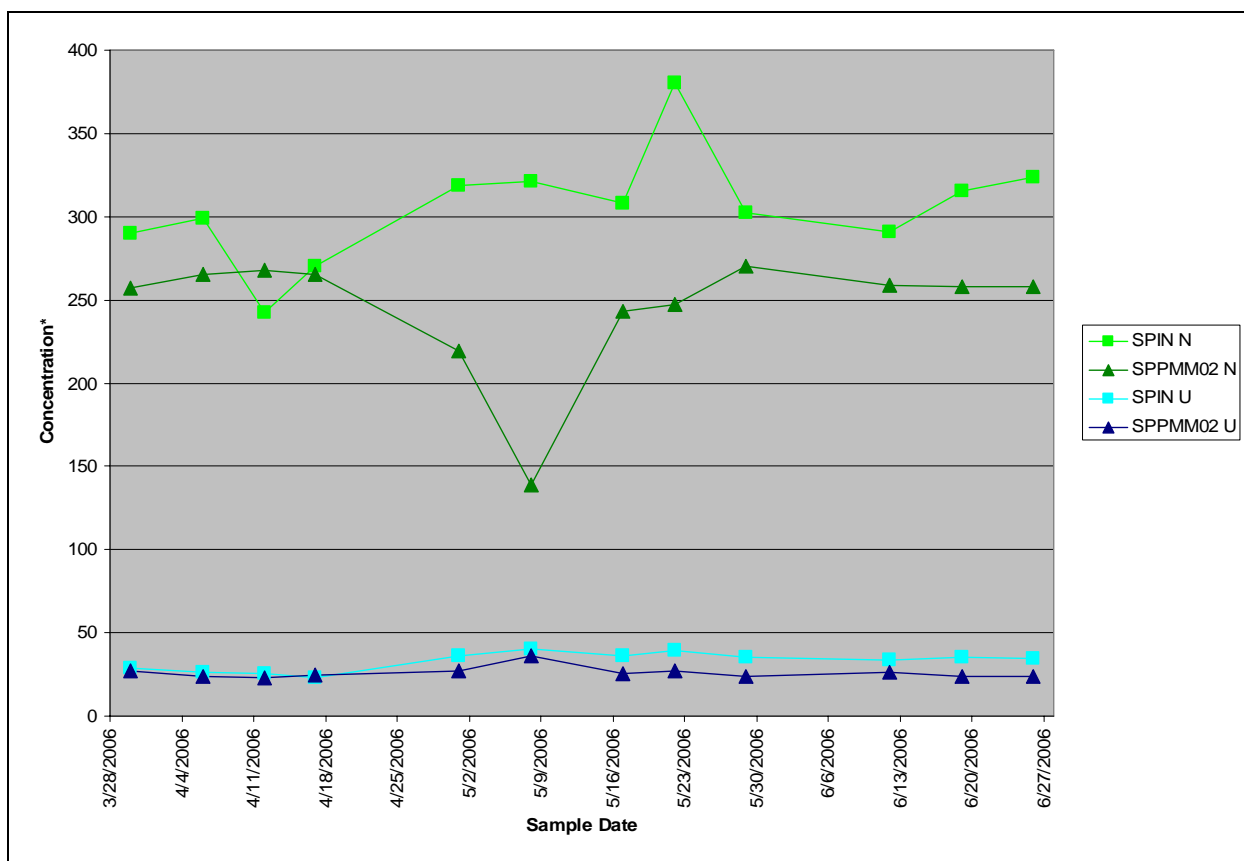
- Truncated original influent line to prevent recirculation and address broken line
- Replaced main influent line “Y”
- Stabilized influent line from collection well pump to prevent further kinking
- Replaced all valves with new valves
- Replaced distribution gallery and used flexible hose to allow settling
- Sealed penetrations through cell walls
- Reconnected west cell effluent vent riser
- Stabilized all vent risers.

The sawdust media was found to be acceptable for continued use and was not replaced.

As a part of these evaluations, differences in water quality between the traditional influent location and the actual influent were characterized. When the system was first installed, influent water quality was approximated via samples from a piezometer located near the deepest part of the ground water intercept trench. In 2002, the collection well was installed and water was pumped from there into the system. This latter location is approximately 10 yards from the traditional location and, by definition, represents true system influent. However, influent samples continued to be collected at the original location (known as both piezometer 71099 and sample location SPPMM02) because the decision document for the SPPTS (DOE 1999b) specified this as the monitoring location for influent. The Site Corrective Action Decision/Record of Decision (CAD/ROD) and post-closure agreement would afford a convenient opportunity to replace this pseudo-influent location with the real influent location. Samples were collected at both locations. The true influent, as represented by samples collected from the collection well (which has been given the location name SPIN), has been found to contain water with concentrations of nitrate and U that are significantly higher than in samples collected from the traditional location, SPPMM02. On average, this difference is approximately 20 percent. Figure 3–15 illustrates these differences.

Following these repairs, flow through the system was resumed. Samples collected following repairs indicate nitrate treatment was restored, and concentrations of nitrate in system effluent returned to typical levels (generally below 1 mg/L as N).

Concentrations at the SPP Discharge Gallery were not significantly affected by the repairs, except for a short-duration decrease when the system was put back in operation immediately following the repairs. (This is thought to be a result of the sudden influx of higher-than-normal flows of treated water, causing dilution of the water discharged at this location. After flows returned to normal, concentrations at this location increased again.)

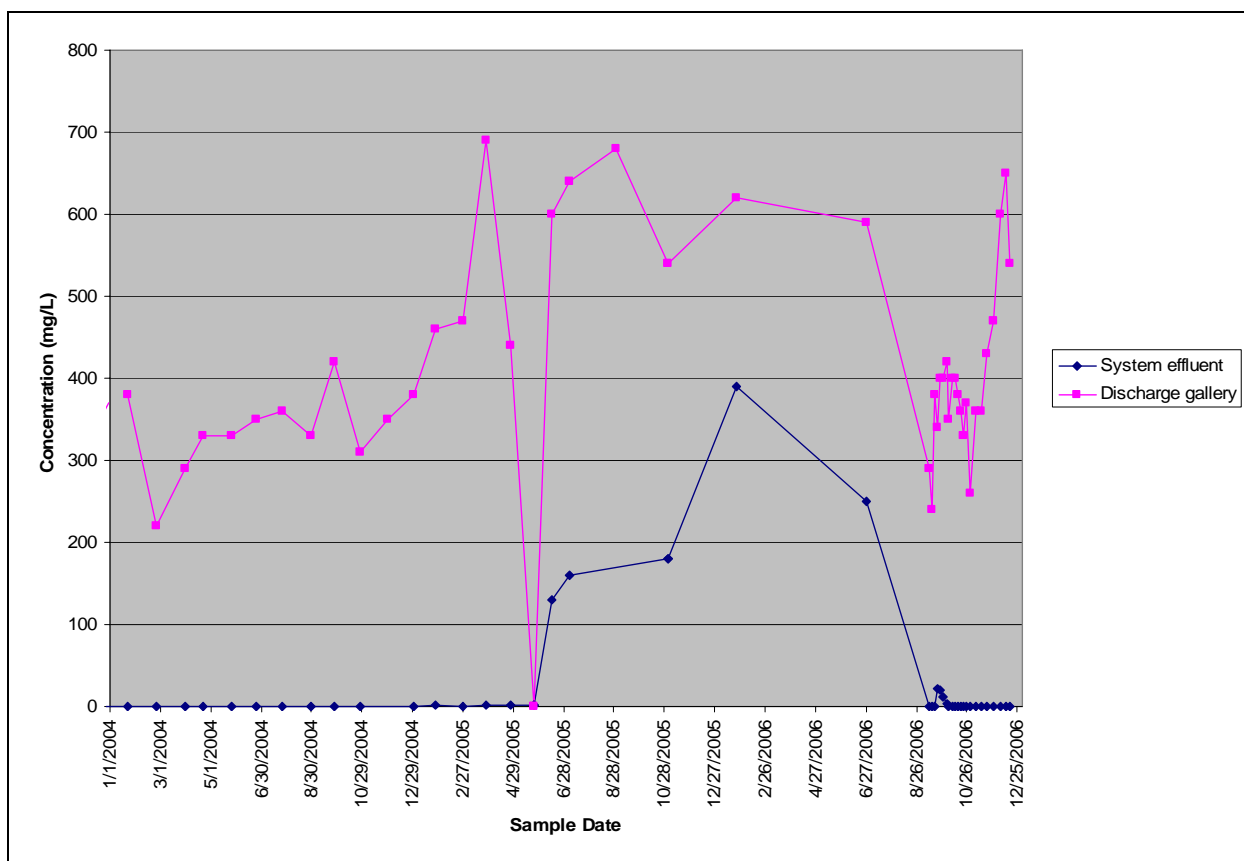


NOTES: *Concentration for nitrate results are nitrate/nitrite as N in mg/L; U results are total U in µg/L. N = nitrate/nitrite as N, U = total U. All results are from field screening samples analyzed by the Environmental Sciences Laboratory in Grand Junction, CO, which is operated by S.M. Stoller Corp. for DOE-LM.

Figure 3–15. Nitrate and Uranium in Water Samples from the Traditional SPPTS influent Sampling Location, SPPMM02, vs. Actual Influent Collected from SPIN

The effects of the initial valve reconfiguration and the repairs described above are shown using analytical data provided by contract laboratories (as opposed to field screening samples) on Figure 3–16.

In addition to this and the routine maintenance, treatability studies were begun at the SPPTS. This effort is discussed in Section 3.5.

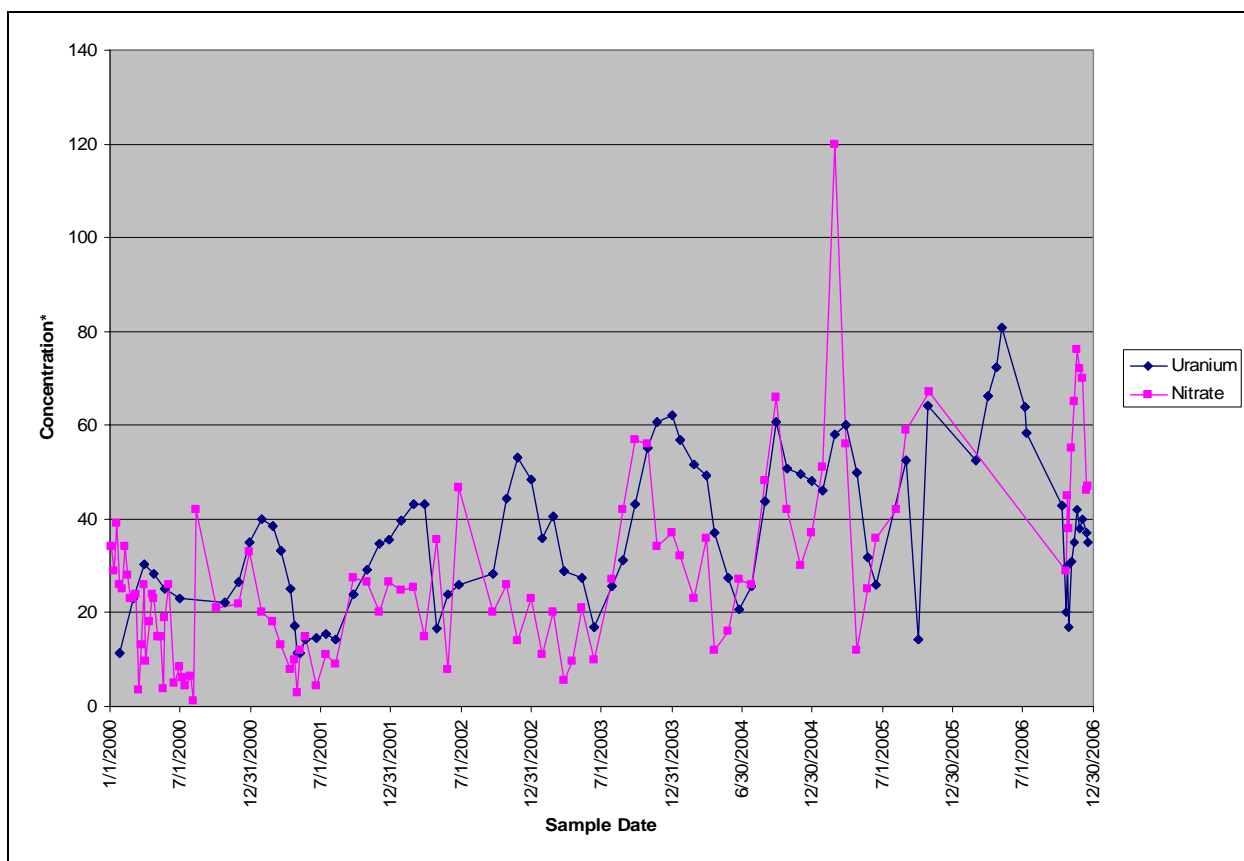


Note: Formal name of "System effluent" location is SPPMM01; formal name of "Discharge gallery" is SPPDISCHARGE GALLERY, but has been reported using that name, SPP Discharge Gallery, SPP DisGal, and other permutations. Many of the lowest-concentration effluent results are nondetects (U-qualified) but are not shown as such for simplicity.

Figure 3–16. Concentrations of Nitrate in SPPTS Effluent and Discharge Water

Water quality at the performance monitoring location for the SPPTS, GS13, is generally consistent with previous data. Concentrations of nitrate are below the Temporary Modification stipulated in the RFCA (CDPHE, DOE, and EPA 2003). Even so, the trend of nitrate concentrations at this surface water location is increasing (see S-K trend plot for GS13 in Appendix B.3). One factor is that the water exiting the SPPTS at the SPP Discharge Gallery began to take a shortcut directly to North Walnut Creek rather than flow along its designed path. This condition was corrected in 2006 by restoring the flow to its intended path, and should result in decreasing nitrate concentrations at GS13.

The historic pattern of U concentrations—higher in the winter, lower in the summer—suggests the relative contributions of runoff and ground water discharge to North Walnut Creek. Now that impermeable surfaces such as parking lots, roads, and buildings have been removed, the amount of runoff has decreased sharply. Ground water now comprises a larger fraction of the surface water than in years past. At GS13, this may result in some smoothing of the pattern shown on Figure 3–17, and a generally higher average U concentration.



NOTES: *U concentration in $\mu\text{g/L}$, nitrate concentration in mg/L nitrate/nitrite as N. Many of the U data are converted from isotopic activities to mass units, as described in the text.

Figure 3–17. Uranium and Nitrate at SPPTS Performance Location GS13.

S-K trend plots were constructed for locations at the SPPTS including the traditional influent location (SPPMM02, a.k.a. piezometer 71099), effluent (SPPMM01), discharge gallery, and GS13. These are provided in Appendix B.3. Summarizing, the trend for all four locations is increasing for nitrate at a 95 percent level of confidence, and for three of the four locations for U at the same level of confidence. U is not increasing at the 95 percent level of confidence at location SPPMM02.

Visual examination of the trend plots (Appendix B.3) illustrates the significance of the most recent data in determining the slope of the trends at SPPMM02. Those slopes are estimated at 0.1309 for U, and 0.03326 for nitrate—both extremely gentle increases and very close to no slope. These statistical evaluations underscore the importance of the repairs that were performed in 2006 to the SPPTS. As additional data are collected, the trends should decrease to zero slope at SPPMM01. And as discussed above, if the anticipated increases in U concentrations at GS13 hold true, the increasing trend at that location will continue until steady-state conditions have been reached. This applies equally to nitrate, since it too is in the ground water in this area at an elevated concentration.

Refer to the quarterly reports (DOE 2006f, 2006g, 2007d) and Appendix B.6 for additional analytical data from SPPTS monitoring locations.

The SPPTS treated approximately 251,000 gallons in 2006. This is generally consistent with volumes treated since the system was modified with the addition of the pump. In 2003, the system treated 340,000 gallons, in 2004 it treated 230,000 gallons, and in 2005 it treated 140,000 gallons. Repairs made in August–September 2006 will act to increase flow through the system, since these repairs included fixing numerous leaks. However, the general decrease in flow that may result because of the removal of previous Site contributions could counteract this.

3.3.3 Other Plumes

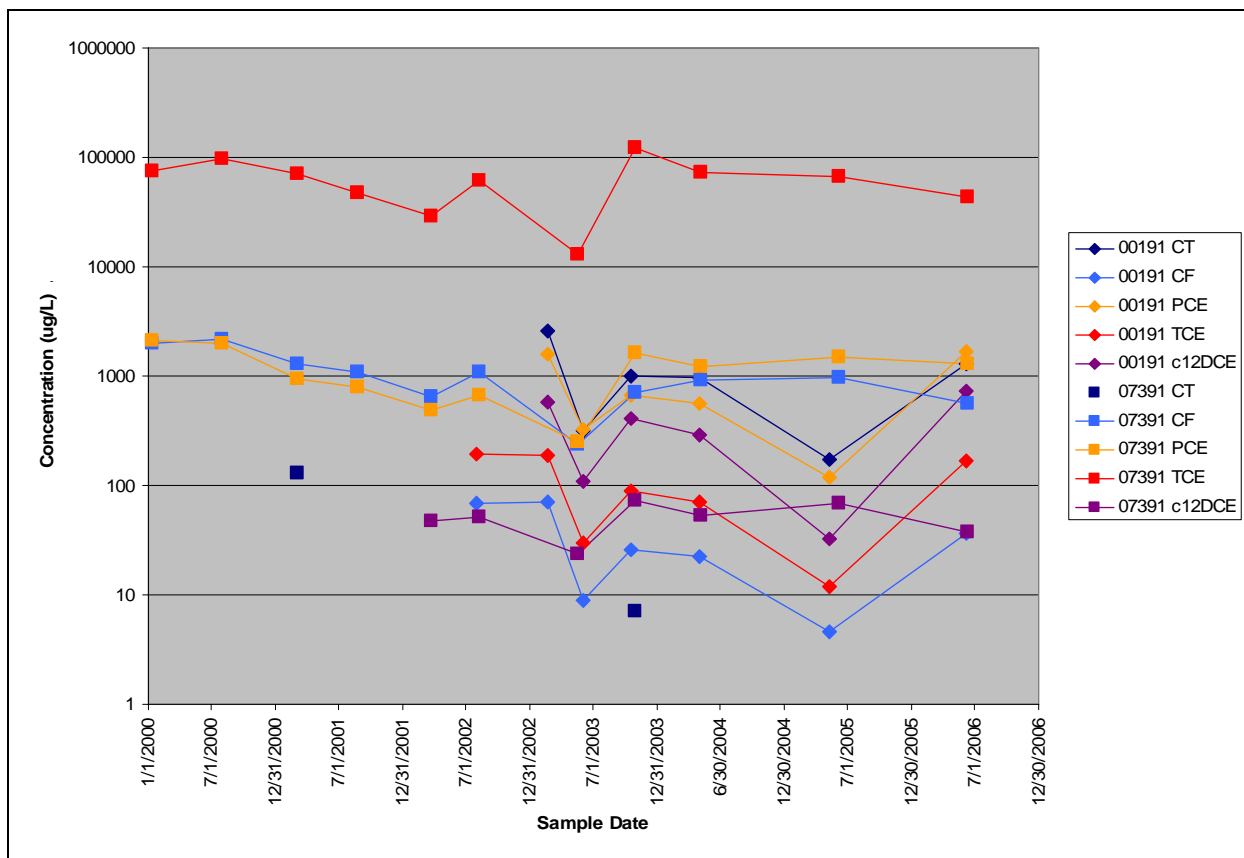
In accordance with the IMP, several other ground water contaminant plumes were monitored during 2006. These include the 903 Pad/Ryan's Pit Plume, the collection of small plumes collectively referred to as the IA Plume (and often discussed, as in this report, in terms of the South and North IA Plume), the Vinyl Chloride Plume (or OBP #1 Plume) located south of former B371, the OBP#2 Plume located immediately west of the Mound Plume, the Individual Hazardous Substance Site(s) (IHSS) 118.1 Plume located north-northwest of former B776, the Property Utilization and Disposal (PU&D) Yard Plume, and the OU1 Plume.

3.3.3.1 903 Pad/Ryan's Pit Plume

The 903 Pad/Ryan's Pit Plume was monitored in 2006 via several wells distributed within and at the margins of the plume. This plume bifurcates, with one portion flowing toward the southeast and Woman Creek, and the other flowing toward the northeast and joining the East Trenches Plume. The northeastern branch is not discussed here; refer to the text on the East Trenches Plume above.

Water quality within the southeastern portion of the 903 Pad/Ryan's Pit Plume appears consistent with that reported in previous years. AOC well 10304, located south of the SID and just east of Pond C-1, monitors for VOCs that may be reaching the Woman Creek drainage from this plume. None of the 903 Pad/Ryan's Pit Plume VOC constituents were detected; only a J-qualified detection of acetone (3.9 µg/L), a common lab contaminant, and a detection of styrene (1 µg/L) were reported. The RFCA Attachment 5 (CDPHE, DOE, and EPA 2003) action levels for these constituents in surface water are 3,650 µg/L and 100 µg/L, respectively.

This plume is also monitored by downgradient Sentinel wells 90299 and 90399, source-area Evaluation wells 00191 (just east of the former 903 Pad) and 07391 (just south of the former Ryan's Pit), and in-plume Evaluation wells 90402, 50299, 00491, and 90804. These wells show contamination consistent with the source constituents, with the 903 Pad source being enriched in carbon tetrachloride relative to the PCE-TCE chain of compounds, though concentrations of PCE approach those of carbon tetrachloride. Conversely, ground water contaminated by Ryan's Pit contains much more TCE relative to carbon tetrachloride, which is frequently not detected. (Detection of carbon tetrachloride in well 07391 is hampered by interference from other compounds present at high concentrations, requiring samples be diluted significantly prior to analysis; as a result, detection limits reported for carbon tetrachloride have been as high as 5,000 µg/L since 2000.) Figure 3–18 shows time-series plots of carbon tetrachloride and its daughter product, chloroform, as well as PCE and its daughter products TCE and cis-1,2-DCE. Note that some daughter products, particularly TCE, were heavily used during production at the Site and therefore do not always represent true “daughter products.”



NOTES: CT = carbon tetrachloride, CF = chloroform, c12DCE = cis-1,2-DCE. Of the CT data from well 07391 since 1/12000, only two results are detections, the other ten are nondetects. Both detections are shown. RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): CT, 5; CF, 5.7; PCE, 5; TCE, 5; cis-1,2-DCE, 70. Not shown are U-qualified data for CT from well 07391, as discussed, nor U-qualified data for c12DCE from well 07391 that precede the first 2002 data point shown for this constituent at this location. Several other results were qualified (D, E, J), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

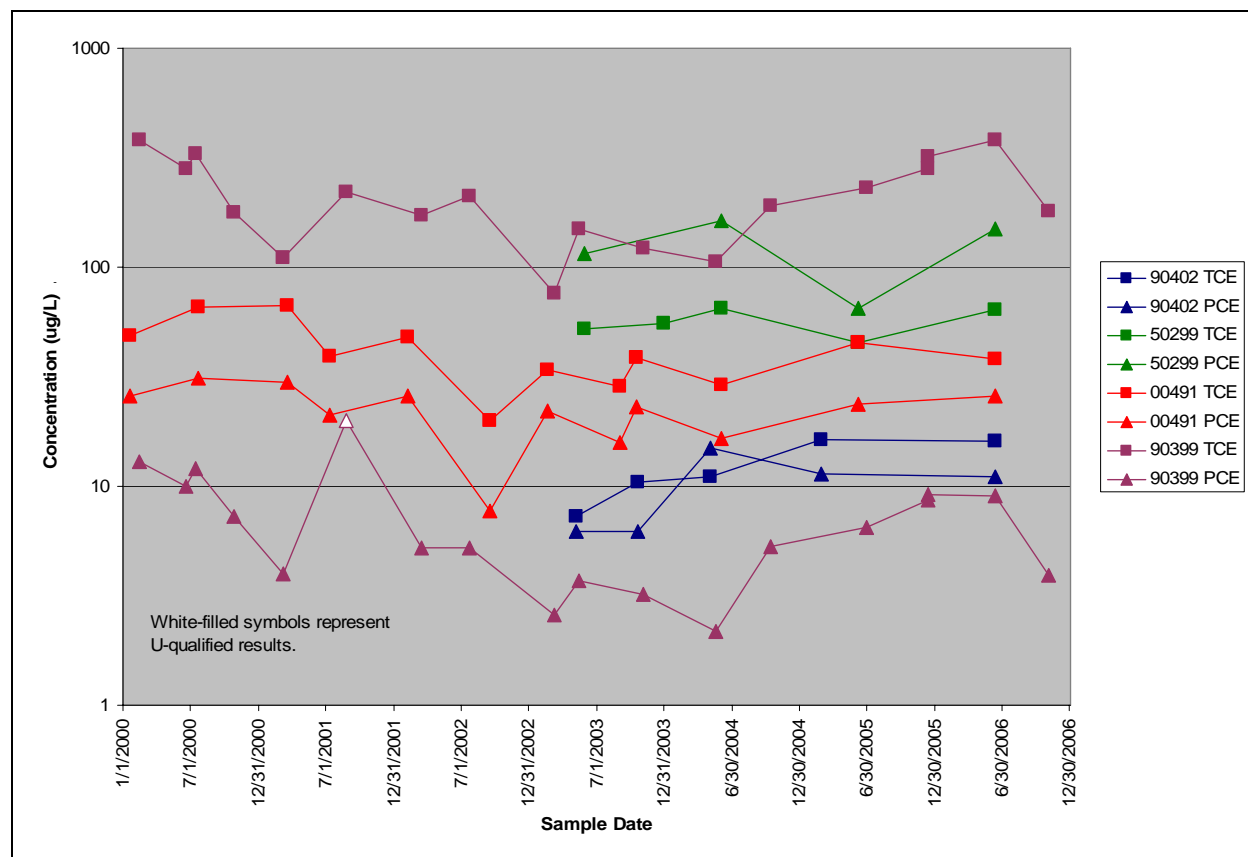
Figure 3–18. Concentrations of VOCs in Source-Area Wells 00191 (903 Pad) and 07391 (Ryan's Pit)

As is evident on Figure 3–18, the relative concentrations of different VOCs in the 903 Pad and Ryan's Pit source areas are different. Constituent concentrations measured in samples from well 00191 vary uniformly from one sample to the next, and show the 903 Pad contaminants to be marked by higher concentrations of carbon tetrachloride than TCE. This is the opposite of conditions at Ryan's Pit. Over time, the HRC application prior to Site closure should be manifested in decreasing concentrations of parent compounds and increasing concentrations of daughter products at source-area wells.

Concentrations in 2006 were generally consistent with previous data, though results from well 00191 in May 2005 had suggested a decrease that has not been confirmed by the 2006 data. In addition, the S-K trend plot for well 90299 shows a statistically-significant (95 percent) decreasing trend in TCE concentrations (which are consistently below 5 µg/L) at that well. See Appendix B.3 for the S-K trend plots, which are also summarized above in Section 3.3.1 and Table 3–5.

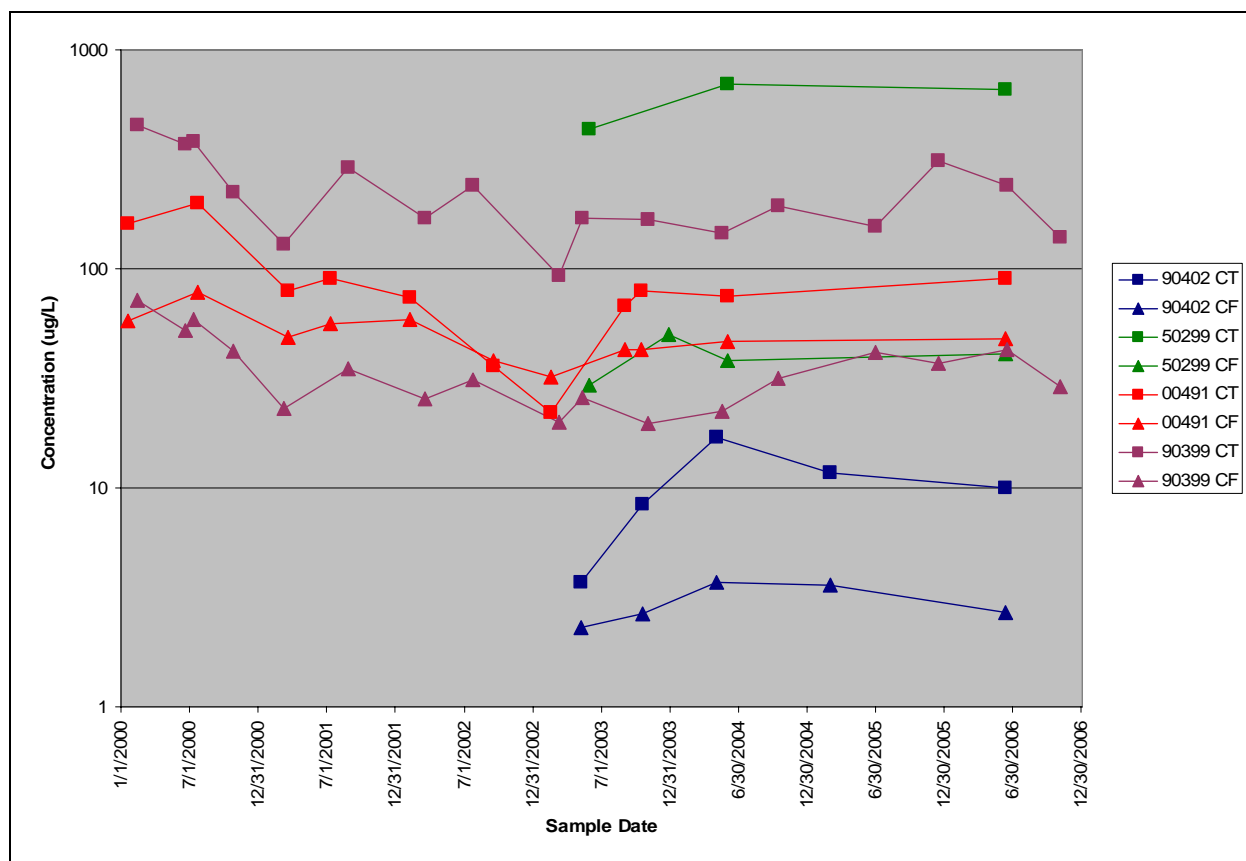
Similar plots of concentrations in downgradient wells, focusing on carbon tetrachloride, chloroform, PCE, and TCE, are presented in Figure 3–19 and Figure 3–20. As with samples

from source-area wells, concentrations of the different VOCs at each well are seen to vary uniformly from one sample to the next. The distribution of PCE and TCE in samples from well 90399 suggest a significant contribution from the Ryan's Pit source area (as represented by the contaminant distribution seen in time series plots for well 07391; see Figure 3-18), given the higher concentration of TCE relative to PCE at Ryan's Pit. Biodegradation of the PCE to TCE may also be contributing to the higher TCE concentrations, but previous reports suggest this mechanism would be of minor importance (K-H 2004a).



NOTES: RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): TCE, 5; PCE, 5. In addition to the nondetects (U-qualified results), several other results were qualified (D, J), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3-19. PCE and TCE in Downgradient 903 Pad/Ryan's Pit Plume Wells



NOTES: CT = carbon tetrachloride, CF = chloroform. RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): CT, 5; CF, 5.7. In addition to the nondetects (U-qualified results), several other results were qualified (D), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–20. Carbon Tetrachloride and Chloroform in Downgradient 903 Pad/Ryan's Pit Plume Wells

As noted in the 2005 Annual Report (DOE 2006e), HRC was emplaced in the subsurface in the 903 pad and Ryan's Pit source areas. The effects of this are not yet evident in samples from the source-area wells.

Refer to the quarterly reports (e.g., DOE 2006f, 2006g, 2007d) and Appendix B.6 for analytical data.

3.3.3.2 IA Plume

The IA Plume is actually a collection of several small VOC plumes grouped together for convenience and, in some cases, because of uncertainties regarding specific sources.

The South IA Plume is monitored by AOC well 11104. This well, sampled during the second and fourth quarters of 2006, showed very low, J-qualified (estimated) results for acetone, a common lab solvent, and 1,3-dichlorobenzene. In addition, concentrations of U, samples for which are collected because of proximity of the OLF and former B444, were well below the U threshold in the IMP (DOE 2006c).

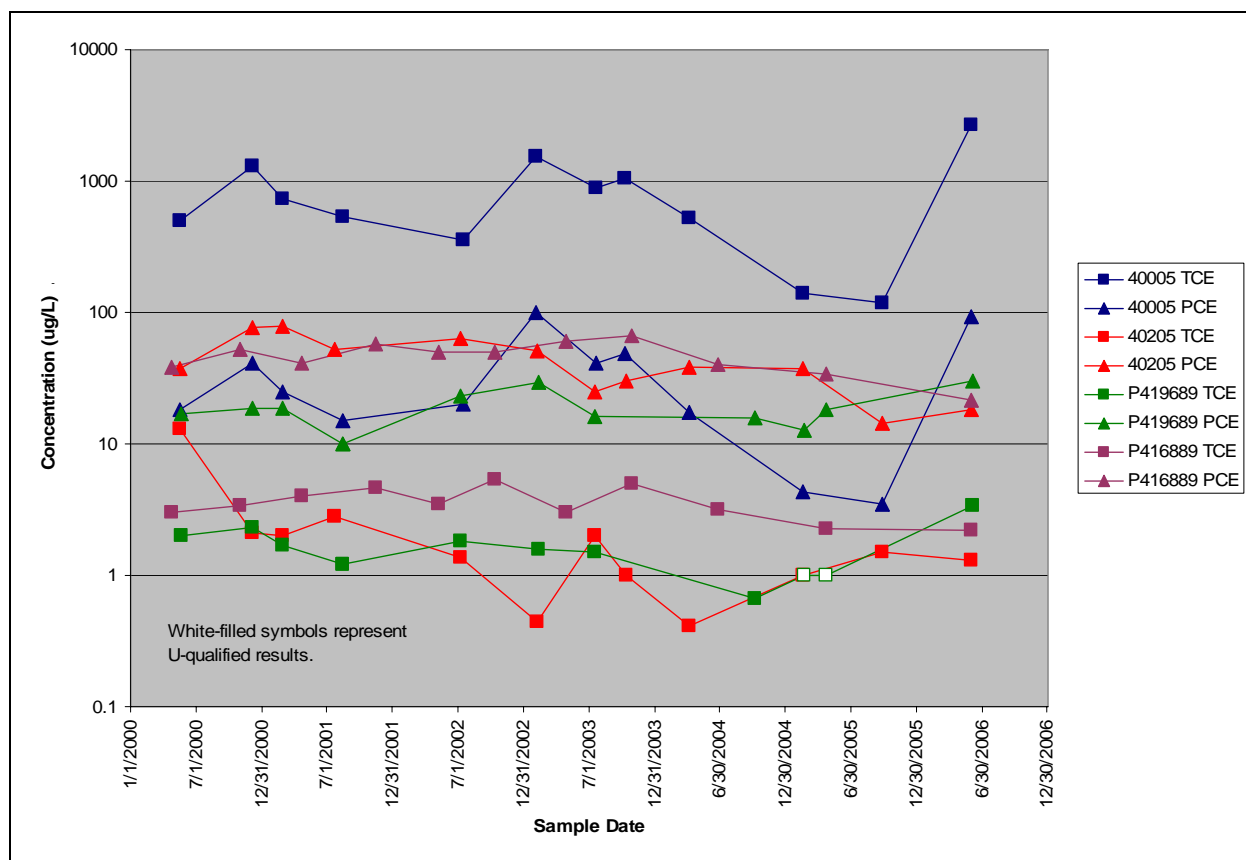
Upgradient of well 11104, wells monitoring the South IA Plume include Sentinel wells 11502 and 40305, and Evaluation wells 40005, 40205, P419689, and P416889. While results from samples collected in 2006 from the Sentinel wells indicate little change, those from the Evaluation wells vary more sharply. Each of the three Evaluation wells surrounding the former B444 complex, 40005, 40205, and P419689, show increases in PCE and TCE concentration in 2006 (Figure 3–21). The only exception is TCE at well 40205. Compared with samples collected most recently, these increases vary in magnitude from just a few parts per billion (ppb; e.g., TCE at well P419689 increased from nondetect to 3.4 µg/L) to over 2,500 ppb (TCE at well 40005 increased from 117 µg/L to 2,650 µg/L). The sharpest increases are seen at well 40005, located immediately west of the former B444 complex and traditionally producing ground water samples with the highest concentrations of VOCs of all B444 wells. A short distance downgradient, well P416889 shows slight decreases in PCE and TCE concentrations; nearby Sentinel well 11502 (not shown on Figure 3–21) produced samples with lower concentrations of PCE and TCE that also show a slight decrease compared to samples collected in 2005. These data may be indicative of the effects of the removal of impermeable surfaces (pavement and buildings) from this area, together with the disruption of the foundation and storm drains here and the waning effects of dilution and flushing from dust suppression water applied during B444 closure. Analytical data from future samples may show continued increasing concentrations at well 40005 in particular as the water applied during closure of the B444 facility moves out of the area, the ground water receives direct recharge, and geochemical conditions stabilize.

Also evident on Figure 3–21 is the different contaminant distribution at well 40005 as compared to the other wells. At 40005, concentrations of TCE are significantly greater than those of PCE; the opposite is true at wells 40205 and P419689. Refer to K-H (2002b) for additional discussion on possible historical influences at well 40005.

The S-K trend plots for well 40305 are notable, as statistically-significant (95 percent) trends are calculated for TCE (decreasing) and methylene chloride (no slope). However, both are artificial trends: there has been no detection of either compound reported since 2001. See Appendix B.3 for the S-K trend plots, which are also summarized above in Section 3.3.1 and Table 3–5.

The North IA Plume is monitored by AOC well 42505. This well was sampled twice in 2006, and reported no confirmed detections of VOCs.

This area is also monitored by numerous other wells (Figure 3–1). Analyses of samples from well 55905, located on the north side of former B559, show concentrations of carbon tetrachloride have declined following the elevated result in 2005 (from 120 µg/L in 2005 to 65 µg/L in 2006). Concentrations of this constituent in nearby well 56305 (located on the west side of former B559) also decreased somewhat from 136 µg/L to 110 µg/L over the same period. Other VOCs (such as PCE and TCE) have decreased in concentration at well 55905, but are still above their pre-closure averages in well 56305. Again, all of this is probably related to factors such as the removal of impermeable surfaces and gradually stabilizing hydrological and geochemical conditions.

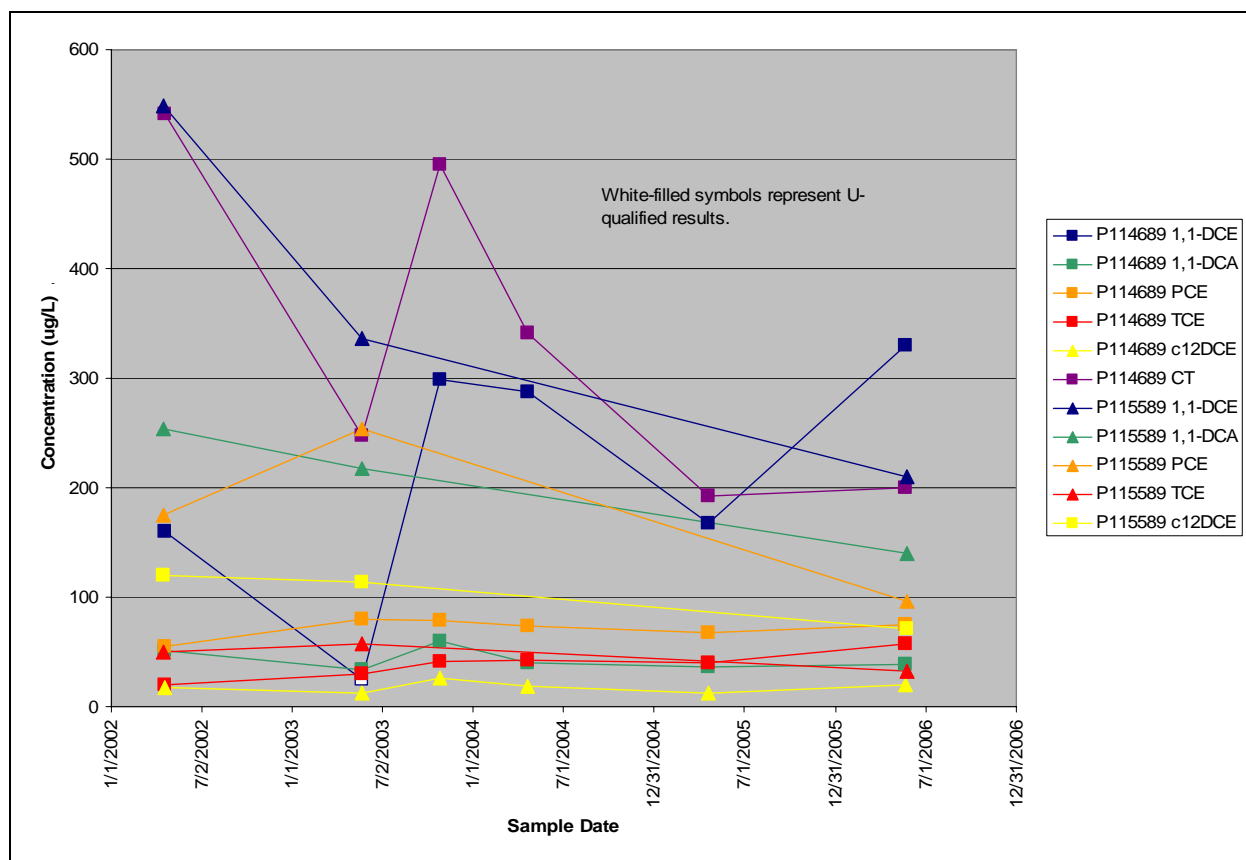


NOTES: Curves for wells 40005 and 40205 include data from their predecessors, 40099 and 40299, respectively. RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): PCE, 5; TCE, 5. In addition to the nondetects (U-qualified results), several other results were qualified (J, E, D), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3-21. PCE and TCE in South IA Plume/B444 Wells

Ground water samples collected in 2005 from well 70705, located on the east side of former B707, indicated a sharp increase in carbon tetrachloride concentration. This has not continued through 2006; this constituent was most often not detected in the original well, 00200, from 2000 through 2003 (highest concentration: 1.4 µg/L in November 2000). It was then reported at a concentration of 163 µg/L in the sample collected from replacement well 70705 in September 2005. The sample collected in 2006 reported a concentration of carbon tetrachloride of 2 µg/L.

Farther west, concentrations of VOCs in wells P114689 and P115589 are either consistent with past ranges or are declining, with two notable exceptions. Concentrations of TCE in ground water from well P114689 appear to be steadily increasing. In addition, concentrations of 1,1-DCE have also increased here, as shown in Figure 3-22. This compound is a common breakdown product of 1,1,1-TCA, PCE, TCE, and 1,2-DCE. None of these is present at levels similar to that of 1,1-DCE. At well P115589, concentrations of 1,1-DCE appear to be decreasing, as are concentrations of PCE, TCE, and other VOCs.



NOTES: c12DCE = cis-1,2-DCE, CT = carbon tetrachloride. RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): 1,1-DCE, 7; 1,1-DCA, 3650; cis-1,2-DCE, 70; PCE, 5; TCE, 5. In addition to the nondetects (U-qualified results), several other results were qualified (D), but are not shown differently for the sake of simplicity.

Figure 3–22. Concentrations of VOCs in IA Wells P114689 and P115589

Collectively, these changes in North IA Plume ground water may indicate mobilization of residual contamination that had been stationary due to the presence of impermeable surfaces (pavement, buildings) in this area. Removal of those surfaces and subsequent direct recharge of the ground water through precipitation (and prior to closure, dust suppression water as well), coupled with the general disturbance and loosening of the ground surface, will act to increase the mobility of VOC contamination from residual sources. Ground water quality in this area will continue to be monitored and assessed in case these conditions begin to pose a potential threat to downgradient surface water.

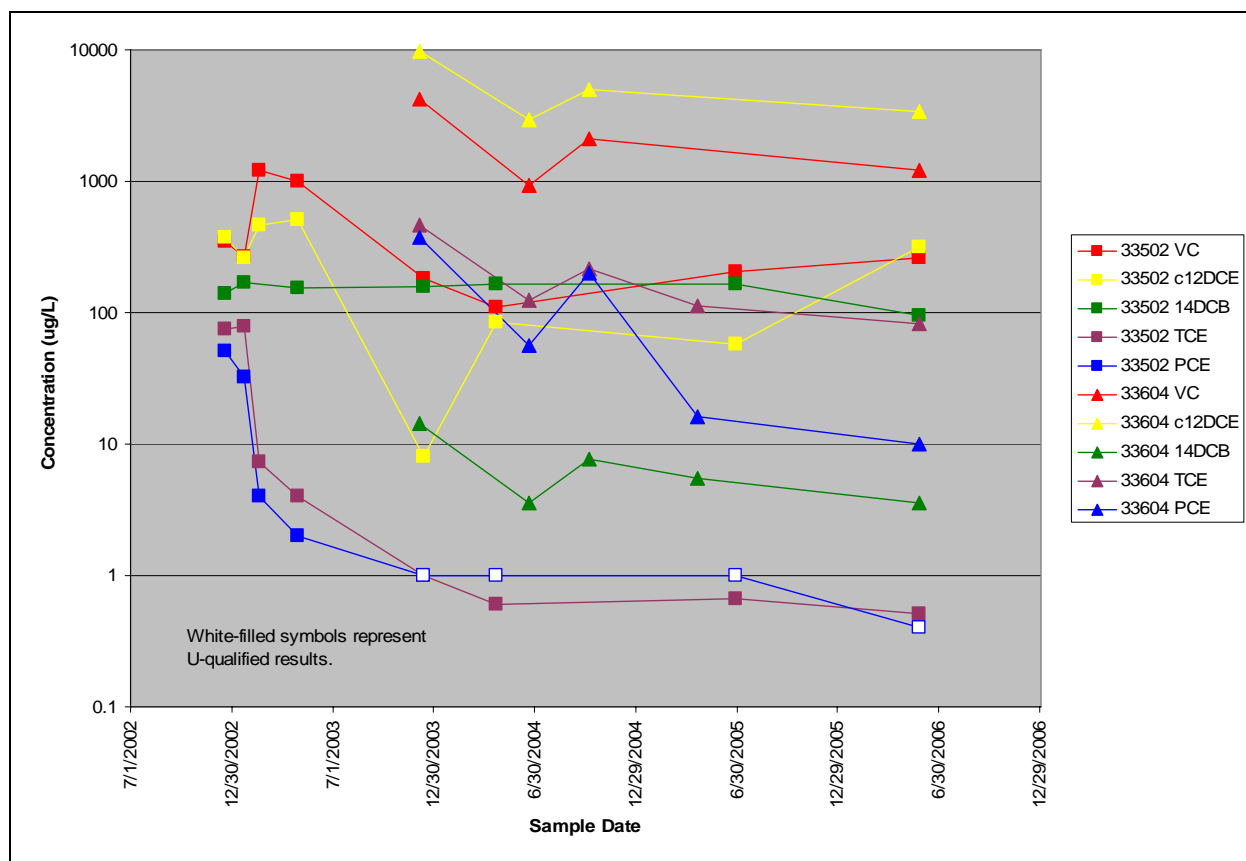
3.3.3.3 Vinyl Chloride Plume

The vinyl chloride plume emanates from OBP#1 and/or the metal disposal/ destruction sites (former IHSSs 134N and 134S). These source areas are on the margin of a valley that was buried during construction of B371 and became the site of the Portal 2 parking lots, among other facilities; the plume resides within that buried valley. Although vinyl chloride was historically detected in many locations at the Site (one study reports vinyl chloride was detected in 44 of 620 wells; K-H 2004d), the only location at which it is present in such elevated concentrations is this plume. Elevated concentrations of vinyl chloride have been reported in Evaluation wells 33502

and 33604 (as well as the latter's predecessor, 33603). The highest concentration reported has been 4,190 µg/L (well 33603, December 4, 2003). These two wells monitor the source area of this plume. Vinyl chloride was detected in Sentinel well 33703, located just over 100 feet immediately north of well 33604, in a sample collected in May 2006, but was not detected in the next sample nor has it been detected prior to that May sample.

Well 33502 is one location at which strong evidence for biodegradation has been found (K-H 2004a), which may explain both the high concentrations of vinyl chloride as well as the extremely limited aerial extent over which it has been observed. This biodegradation is probably a result of the slowly decomposing organic matter remaining from the vegetation that once grew within the valley. This would consume oxygen, providing an anaerobic environment suitable for reductive dechlorination of the chlorinated solvents most commonly found at RFS. Another breakdown product that is present at higher levels in samples from the source area is cis-1,2-DCE.

Parent compounds, such as PCE and TCE, are present in the ground water in this area but at relatively lower concentrations compared with that of vinyl chloride. Reported in the tens to hundreds of µg/L are VOCs including PCE and TCE at well 33604 and 1,4-dichlorobenzene at well 33502. These compounds are displayed via a time series plot in Figure 3–23. As is evident on that figure, the concentrations of vinyl chloride and cis-1,2-DCE in ground water samples collected from well 33502 increased in 2006 (from 207 µg/L to 260 µg/L and from 57.5 µg/L to 320 µg/L, respectively), while concentrations of other compounds are seen to decrease here and in well 33604. This could represent normal variability, or it may indicate continued degradation of parent compounds with a concomitant increase in the concentrations of these daughter products. The decreasing concentrations of PCE and TCE do support continuing biodegradation.



NOTES: VC = vinyl chloride; c12DCE = cis-1,2-DCE; 14DCB = 1,4-dichlorobenzene. RFCA surface water action levels for these constituents (ug/L; CDPHE, DOE, and EPA 2003): VC, 2; cis-1,2-DCE, 70; 1,4-DCB, 75; PCE, 5; TCE, 5. In addition to the nondetects (U-qualified results), several other results were qualified (J, D), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale. Plots for well 33604 include data from its predecessor, 33603.

Figure 3-23. VOCs Present in the Vinyl Chloride Plume Source Area

3.3.3.4 OBP#2 Plume

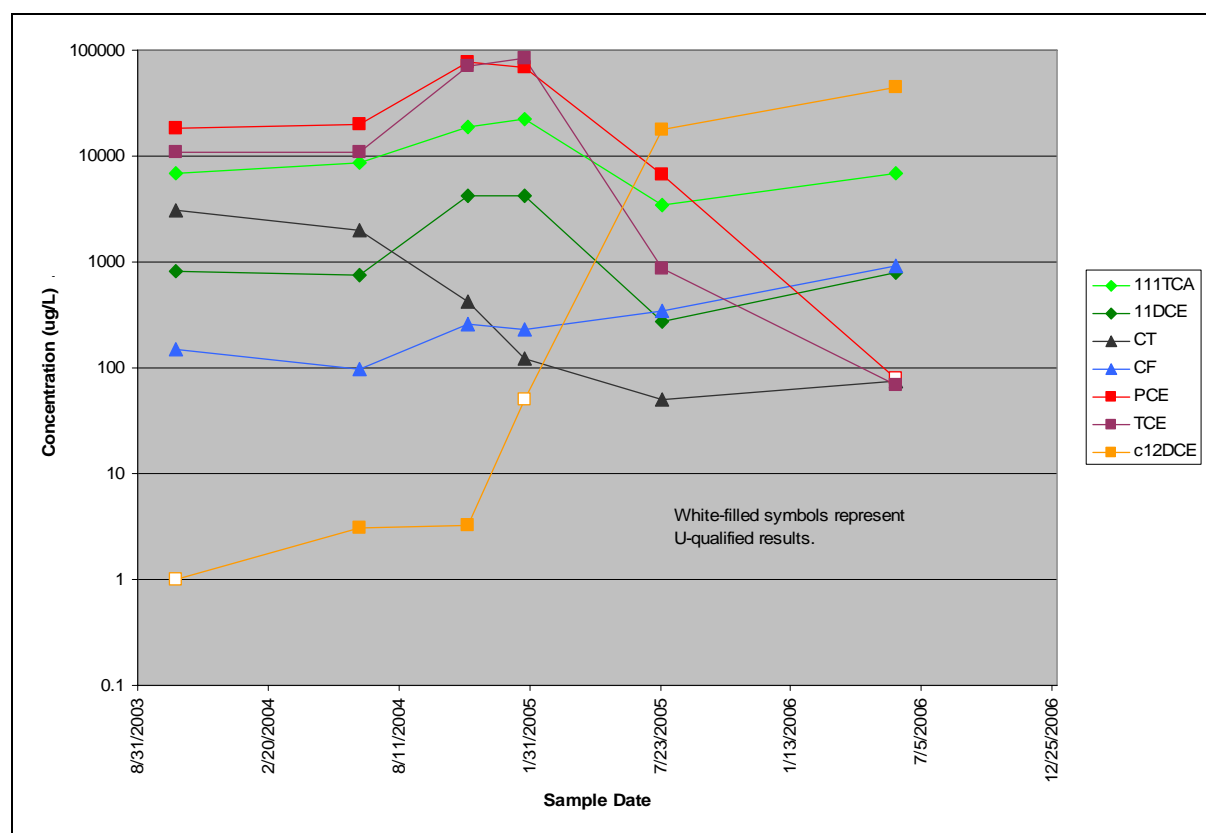
OBP#2 was located at the southeast corner of the former Protected Area (PA) fence just west of the Mound source area. Because of the security infrastructure, ground water monitoring in this location was not feasible until the PA was eliminated. Ground water and soil were subsequently sampled and elevated concentrations of VOCs from OBP#2 were observed.

Ground water in the source area of OBP#2 was first monitored by well 91103. Due to the elevated concentrations of VOCs reported in samples from this well and resulting concerns about the integrity of the PVC of which this well was constructed, stainless-steel replacement well 91104 was installed 10 feet from the original well. Excavation of the source area required abandonment of well 91104, as it was within the excavation boundary. Well 91105 was installed following completion of source removal activities, and is located a few feet downgradient of the downgradient edge of the source removal excavation, just under 75 feet north-northeast from the location of former well 91104. HRC was added to the excavation backfill (K-H 2005b). As a result of the source removal, enhancement of biodegradation, and ultimate location of the replacement well, water quality in samples from well 91105 is not expected to closely resemble that in samples from former wells 91103 and 91104.

Adjacent to the OBP#2 source area was a 72-inch storm drain that potentially acted as a preferential ground water pathway from the source area to South Walnut Creek. As a part of its removal, a trench was cut and backfilled with gravel to divert ground water from the storm drain corridor to the MSPTS intercept trench (K-H 2005b).

The ground water contaminant plume from OBP#2 flows generally northward toward South Woman Creek/FC-4. Previous work has shown the majority of this plume is captured by the MSPTS intercept trench (K-H 2005a), and this behavior was enhanced by the installation of the gravel drain downgradient of the OBP#2 source area (K-H 2005b).

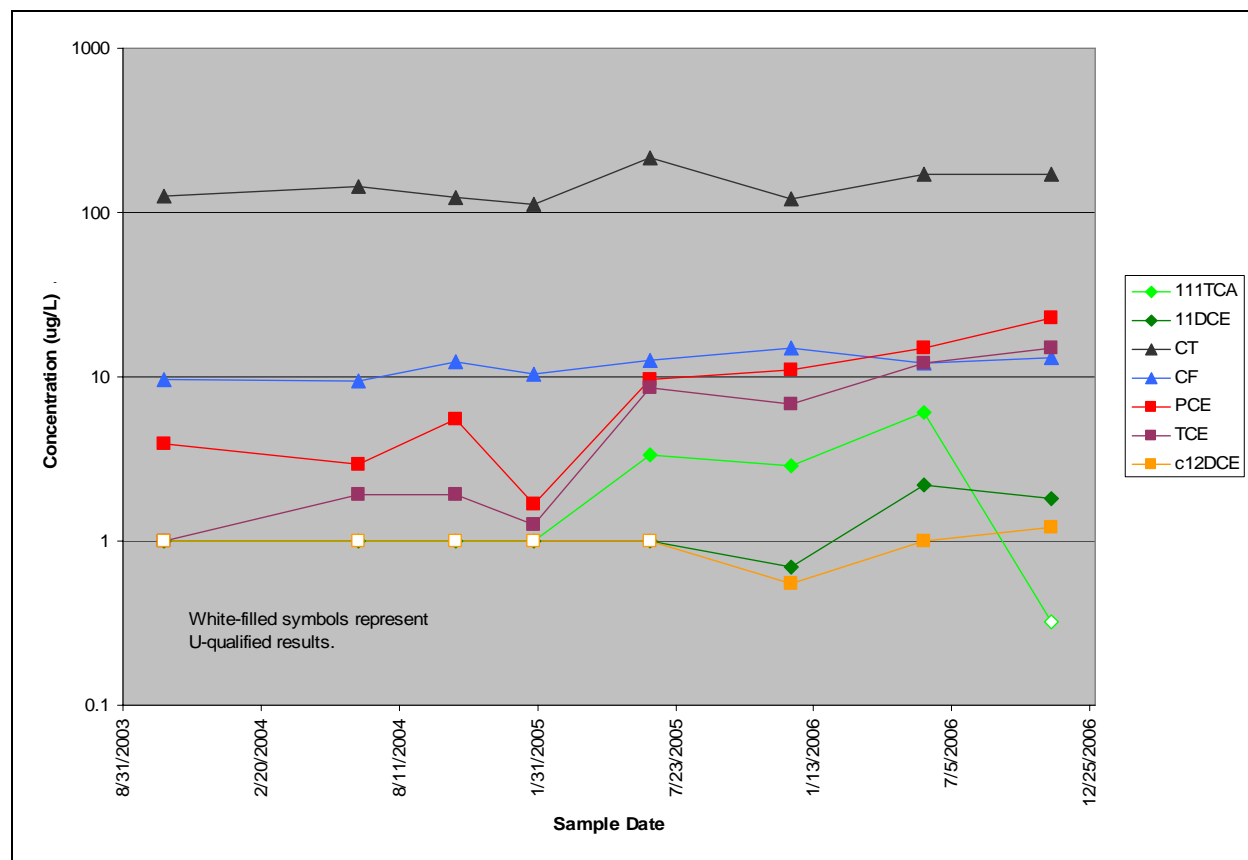
The main VOCs present in ground water samples from the OBP#2 source area are displayed on the time-series plot on Figure 3–24. Evident on this figure are several patterns. First, concentrations of 1,1,1-TCA and its daughter product, 1,1-DCE, vary in concert with one another. This suggests minimal degradation of either compound. Second, concentrations of carbon tetrachloride are generally decreasing, while those of its daughter product chloroform are increasing. This suggests ongoing degradation of the parent product to form additional chloroform. Finally, a similar but stronger pattern is evident with parent products PCE and TCE, both of which are degrading to cis-1,2-DCE, with a corresponding decrease in PCE and TCE concentrations and concomitant increase in cis-1,2-DCE concentrations.



Notes: 111TCA = 1,1,1-TCA; 11DCE = 1,1-DCE; CT = carbon tetrachloride; CF = chloroform; c12DCE = cis-1,2-DCE. RFCA surface water action levels for these constituents (ug/L; CDPHE, DOE, and EPA 2003): 1,1,1-TCA, 200; 1,1-DCE, 7; CT, 5; CF, 5.7; cis-1,2-DCE, 70; PCE, 5; TCE, 5. In addition to the nondetects (U-qualified results), several other results were qualified (J, D), but are not shown differently for the sake of simplicity. Original well 91103 provided samples through June 21, 2004; replacement well 91104 provided subsequent samples through January 26, 2005; and replacement well 91105 provided the balance of the samples. More simply put, the first two samples are from 91103, the middle two are from 91104, and the last two samples shown are from 91105. Note logarithmic scale for concentrations.

Figure 3–24. Concentrations of VOCs in OBP#2 Source Area Well 91105

The same compounds are displayed on Figure 3–25, which is based upon ground water analytical data from well 91203, located north of the OBP#2 source area (Figure 3–1). Samples from this well show relatively uniform concentrations of carbon tetrachloride and chloroform, concentrations of PCE and TCE that tend to vary in tandem with one another, and low to nondetect concentrations of cis-1,2-DCE, 1,1,1-TCA, and 1,1-DCE. These patterns suggest ground water at well 91203 is not strongly impacted by the OBP#2 source area, although the mid-2005 increases in VOC concentrations may be related to source removal activities completed April 1, 2005, and/or to water from the 700 Area that was routed across the surface here in March 2005. Several years of additional data will be needed to evaluate the potential for a hydrologic and geochemical connection, because physical changes to the area as a result of Site closure have been significant and it may take years before the hydrologic system equilibrates. In summary, the contamination observed in samples from well 91203 may have originally come from OBP#2, but how current ground water flow paths are affected by the now-removed storm drain and its replacement gravel drain, the proximity of FC-5, the many changes to the land surface to create and then remove the PA berm, and so forth will require additional data to determine.



NOTES: 111TCA = 1,1,1-TCA; 11DCE = 1,1-DCE; CT = carbon tetrachloride; CF = chloroform; c12DCE = cis-1,2-DCE. RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): 1,1,1-TCA, 200; 1,1-DCE, 7; CT, 5; CF, 5.7; cis-1,2-DCE, 70; PCE, 5; TCE, 5. In addition to the nondetects (U-qualified results), several other results were qualified (J, D), but are not shown differently for the sake of simplicity. Note logarithmic scale for concentrations.

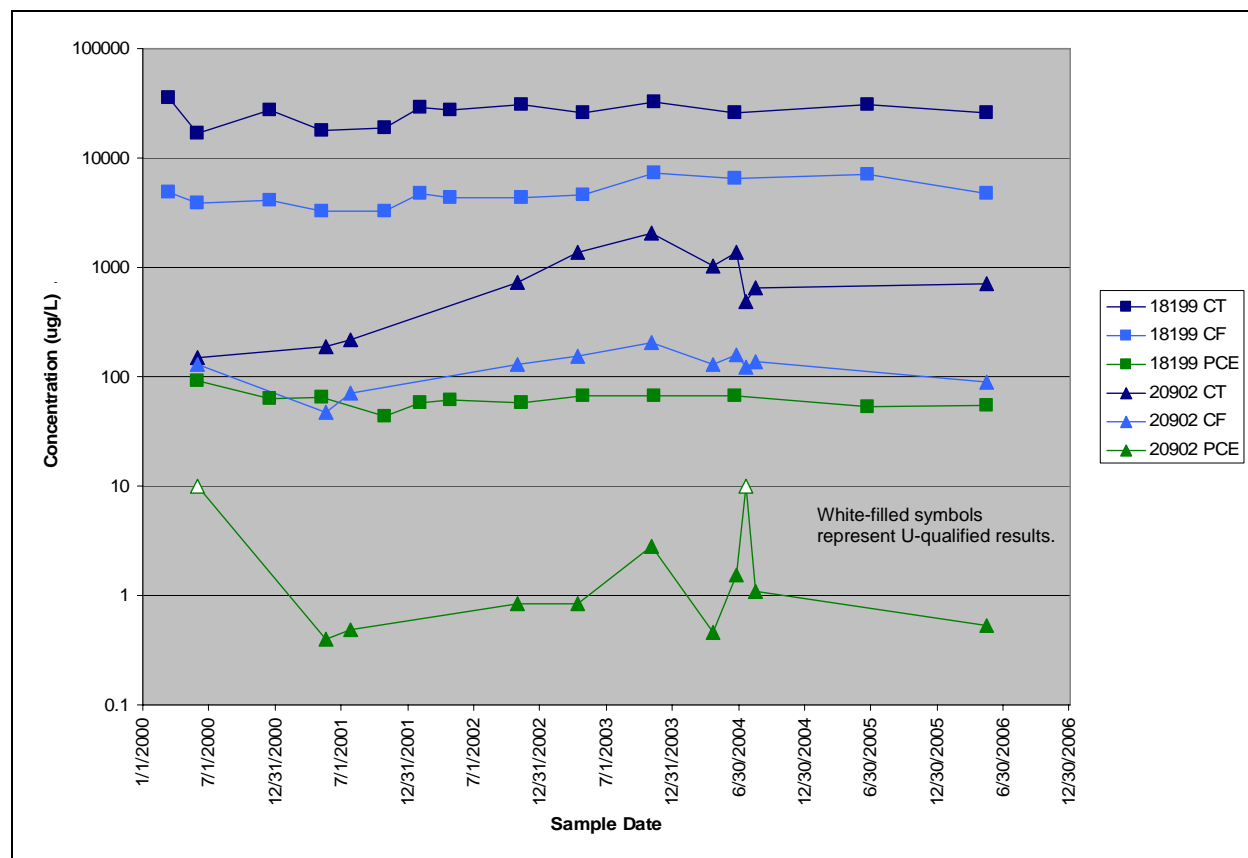
Figure 3–25. Concentrations of OBP#2 VOCs in Downgradient Well 91203

Data from well 91305, located west of well 91203, suggest the OBP#2 source area does not contribute to ground water monitored by well 91305, though cis-1,2-DCE and vinyl chloride have been reported in samples from well 91305.

3.3.3.5 IHSS 118.1 (Carbon Tetrachloride) Plume

The area referred to as the former IHSS 118.1 is the source of a carbon tetrachloride plume. In late 2004, the dense, non-aqueous phase liquid (DNAPL) source material was removed along with an adjacent subsurface tank group referred to as B730. HRC was added to the backfill material to enhance the biodegradation of residual contamination.

Evaluation well 18199 is located on the north of the former IHSS, roughly 80–90 feet north-northwest of the area in which free-phase carbon tetrachloride was present and perhaps 30 feet north of the source-removal excavation boundaries. Concentrations of carbon tetrachloride, chloroform, PCE, and other VOCs from this well in May 2006 are similar to those reported in prior years. To the northwest, well 20902 has also been impacted by IHSS 118.1. Time-series plots are presented in Figure 3–26.



NOTES: CT = carbon tetrachloride; CF = chloroform. RFCA surface water action levels for these constituents (ug/L; CDPHE, DOE, and EPA 2003): CT, 5; CF, 5.7; PCE, 5. In addition to the nondetects (U-qualified results), several other results were qualified (J, D, E), but are not shown differently for the sake of simplicity. Plots for well 20902 include data from its predecessor, 20998. Note logarithmic scale for concentrations.

Figure 3–26. Concentrations of Primary IHSS 118.1 VOCs in Source Area and Downgradient Wells

Concentrations of methylene chloride, another breakdown product of carbon tetrachloride, are also reported in samples from well 18199 but are not shown in Figure 3–26 because of the frequent B qualifiers (indicating laboratory contamination from this common lab solvent). Also not shown are TCE concentrations because of their elevated detection limits and frequent U qualifiers (not detected at the indicated detection limit).

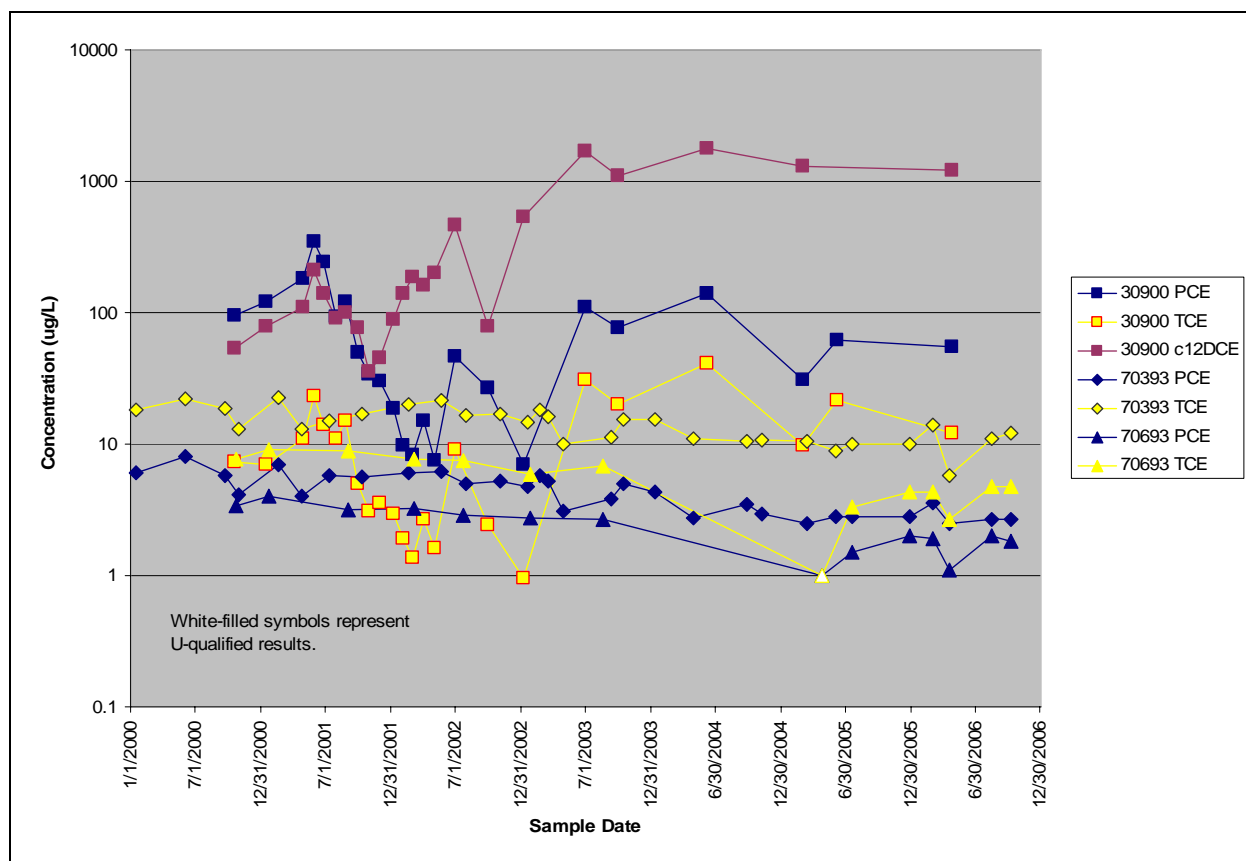
Concentrations of carbon tetrachloride and PCE in samples from source-area well 18199 would be expected to decrease, and those of chloroform increase, following enhancement of biodegradation related to the application of HRC in the backfill following source removal activities. This is not evident on Figure 3–26, but will continue to be assessed. Water quality data from wells 20705, 20505, and 20205 will also continue to be assessed to determine whether a more northerly flow path is established; such a path is not indicated by data collected in 2006. However, S-K trend calculations indicate a statistically-significant (95 percent) increasing trend in U concentrations at well 20705. Even so, the highest results are an order of magnitude lower than the U threshold defined in the IMP (DOE 2006c). See Appendix B.3 for the S-K trend plots, which are also summarized above in Section 3.3.1 and Table 3–5.

3.3.3.6 PU&D Yard Plume

The PU&D Yard Plume is an area of ground water with low concentrations of primarily PCE-family VOCs. This area was the site of the first HRC application performed at RFS, which took the form of a treatability study performed in early 2001 (K-H 2001, 2002a; see K-H 2005a for final detailed information from this study). This plume is monitored by Evaluation well 30900 in the source area and Sentinel well 30002 to the east, at the margin of North Walnut Creek. In addition, PLF Resource Conservation and Recovery Act (RCRA) wells 70393 and 70693 monitor the northern edge of this plume.

Concentrations of PCE, TCE, and cis-1,2-DCE in samples from source-area well 30900 suggest steady-state conditions have been reached in the source area. All three compounds show a leveling off of concentrations, and data from 2006 indicate there is little or no additional degradation of parent PCE and TCE to cis-1,2-DCE resulting from the application of HRC in 2001. Reductive dechlorination of cis-1,2-DCE results in vinyl chloride and/or 1,2-DCA (K-H 2004a), but with the exception of one result of 0.21 µg/L vinyl chloride in July 2001, neither of these constituents have been detected in samples collected from well 30900. This suggests either incomplete degradation of PCE or an alternative dechlorination pathway. Given the limited effective lifetime of HRC and the oxygenated ground water here, this is not surprising.

Concentrations of PCE and TCE in ground water samples from downgradient PLF RCRA wells 70393 and 70693 do not show the same fluctuations as are evident in samples from well 30900 (Figure 3–27). Instead, samples from these RCRA wells continue to show a slight decline in concentrations, apparently unaffected by events in the source area of the PU&D Yard Plume. Cis-1,2-DCE is rarely detected at these locations, with those few detections qualified as estimated and reported at below 1 µg/L.



NOTES: c12DCE = cis-1,2-DCE. This compound is typically not detected at wells 70393 and 70693, and is therefore not displayed. RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): cis-1,2-DCE, 70; PCE, 5; TCE, 5. In addition to the nondetects (U-qualified results), several other results were qualified (J, E, D), but are not shown differently for the sake of simplicity. Note logarithmic scale for concentrations.

Figure 3–27. Concentrations of Primary PU&D Yard Plume VOCs in Source Area and Downgradient Wells

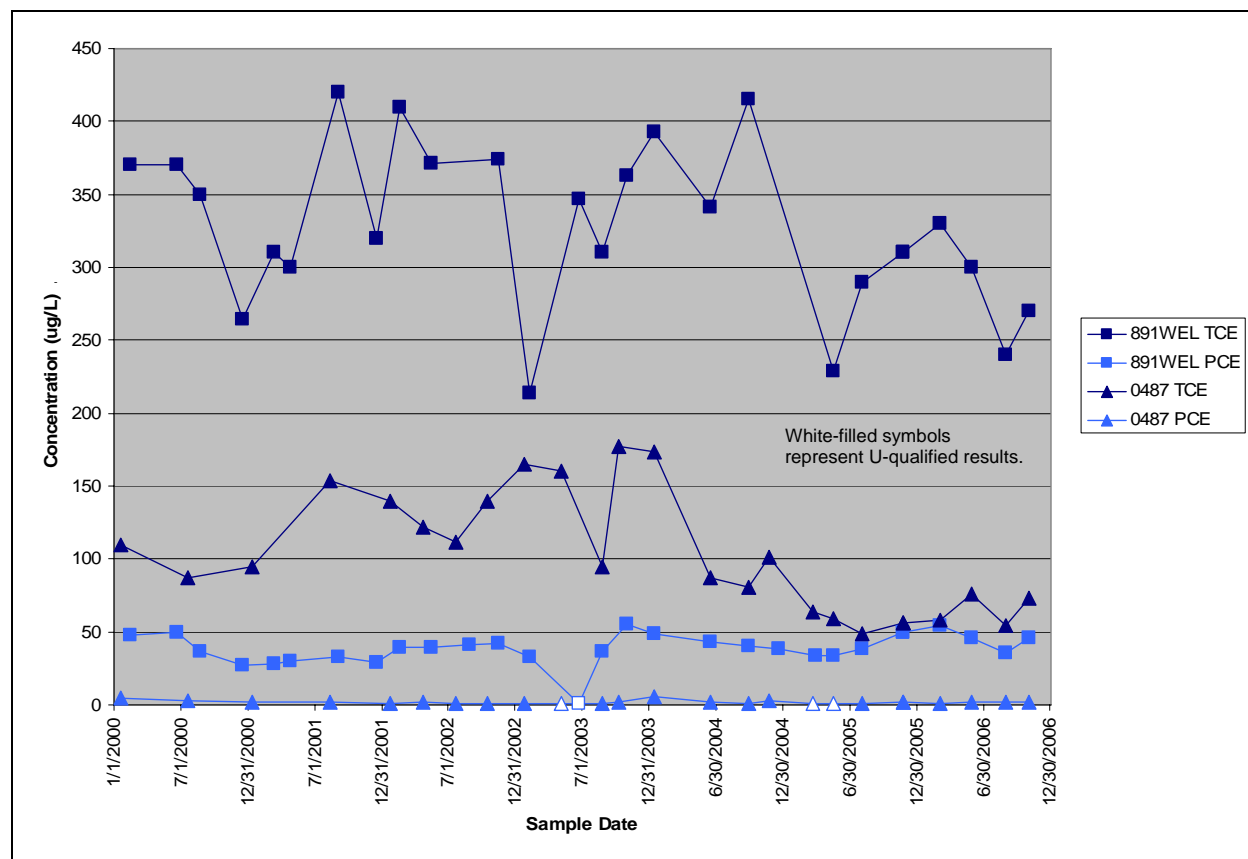
In addition to the analytes displayed on Figure 3–27, as discussed in the 2005 Annual Report (DOE 2006e) well 30900 reports elevated concentrations of two non-chlorinated constituents that are rare or absent in ground water at the Site: acetone (C_3H_6O) and 2-butanone (a.k.a. methyl ethyl ketone, C_4H_8O). Samples collected in 2006 showed a decrease in 2-butanone (from 1,900 µg/L in March 2005 to 880 µg/L in April 2006) and an increase in acetone (from 1,000 µg/L to 1,100 µg/L over the same time period). Both of these chemicals are common laboratory contaminants, but the concentrations reported for ground water samples from well 30900 are far above what would be normal for lab contamination of a sample. Both constituents are readily degraded in the environment (Hazardous Substances Databank). Neither of these analytes are detected in ground water samples from wells 70393 and 70693, but the samples collected from Sentinel well 30002 in November 2005 and in April 2006 reported acetone detections (estimated, J-qualified 3.2 µg/L and 120 µg/L, respectively). The October 2006 sample did not contain a confirmed detection of acetone.

3.3.3.7 OU1 Plume

The OU1 Plume is located on the 881 Hillside, immediately south of the former IA. Its source area, former IHSS 119.1, was a drum and scrap metal storage area. Throughout 2006 this plume

was monitored according to the OU1 CAD/ROD (DOE 2001), which specifies six wells be monitored. Two, Decision Document wells 891COLWEL (now 891WEL) and 0487, are monitored quarterly; the other four (Decision Document wells 4787, 4887, 10992, 11092) are monitored semiannually.

Concentrations of TCE (the constituent of most interest in this plume) in ground water at the OU1 Plume did not change markedly through 2006. Analytical results are displayed on Figure 3–28 for TCE and PCE in source-area well 891WEL (including its predecessor, 891COLWEL) and well 0487, which is located about 135 feet downgradient. TCE was not detected in ground water samples from AOC well 89104, but estimated detections of acetone (62 µg/L) and methylene chloride (0.46 µg/L, also B-qualified, indicating blank contamination) were reported here.



NOTE: Data for 891WEL also include results from its predecessor, 891COLWEL. RFCA surface water action levels for these constituents (µg/L; CDPHE, DOE, and EPA 2003): PCE, 5; TCE, 5. In addition to the nondetects (U-qualified results), several other results were qualified (J, D), but are not shown differently for the sake of simplicity.

Figure 3–28. OU1 Plume VOCs

3.3.3.8 Other Areas

Although not marked by plumes, other areas warrant mention either because associated wells have produced samples with concentration trends having a 95 percent significance (as calculated including results from the fourth quarter of 2006) or because they may be of interest. These are summarized below.

- Former B881: Well 88104 shows a decreasing trend in U, while well 00797 shows an increasing trend in U. Concentrations at 88104, located immediately southeast of the building, are typically at least twice as high as at 00797. Concentrations at both locations are well below the U threshold in the IMP (DOE 2006c).
- Former SW056: Well 45605 is installed within what is now a slump block south of former B991 to monitor ground water that previously exited the hillside via a pipe outlet identified as SW056. (See Section 3.5.1 for additional discussion on the historical context of SW056 and the slump.) Following removal of the pipe and backfilling with HRC, the monitoring well was installed. Whereas the surface water samples from SW056 reported the presence of parent compounds such as PCE and TCE (most recently—July 2005—in the 20–40 µg/L range), samples from the well have continued to report no detections of these constituents. However, detections of vinyl chloride are reported, as well as higher concentrations of cis-1,2-DCE. Both compounds were also reported at SW056, but vinyl chloride was present at higher concentrations (most recently to approximately 12 µg/L in SW056, and an estimated concentration of 0.97 µg/L from 45605) and cis-1,2-DCE was at lower concentrations (most recently approximately 110 µg/L at SW056 and 300 µg/L at 45605). Concentrations of the latter compound have increased through 2006, suggesting continued degradation of parent compounds upgradient of the well.

3.3.4 Ground Water Flow

This section provides summary discussion of ground water elevation and flow characteristics. Ground water elevation data are discussed first, through the construction and interpretation of potentiometric surface maps and hydrographs. Ground water flow characteristics are then assessed, including calculated flow velocities.

Discussions of conditions at the PLF and OLF are presented separately in Section 3.4.

3.3.4.1 Ground Water Elevations

Ground water elevation data were collected at the start of the second and fourth quarters of 2006. (Water level data are included in Appendix A.3.) These data were plotted and hand-contoured to create potentiometric surface maps.

The potentiometric surface maps for 2006 are the first to use new topographic data representing the post-closure land surface. These data were received in early 2007, and are based on an aerial survey performed in the summer of 2006.

The potentiometric surface map for the second quarter of 2006 is included as Figure 3–29, and that for the fourth quarter of 2006 is included as Figure 3–30. Both of these maps are based on water level measurements collected manually from all wells then scheduled and available for measurement. All wells are screened within the upper hydrostratigraphic unit (UHSU) at Rocky Flats, which comprises the unconsolidated surficial materials (e.g., Rocky Flats Alluvium, hillslope colluvium, valley-fill alluvium, and artificial fill—all of which are often loosely referred to as “alluvium”) and underlying weathered bedrock (most often the Cretaceous-aged Laramie Formation, but in some areas also or instead the Cretaceous-aged Arapahoe Formation). While these two components of the UHSU are in hydraulic communication, a well screened

entirely within the weathered bedrock may reflect different water levels from an adjacent well screened only in the alluvium.

Seep areas are also posted on both potentiometric surface maps; these are from the 1995 Hydrogeologic Characterization Report (EG&G 1995b). As such, given the removal of the water supply system and associated reduction in the amount of water available to the Site, as well as the cessation in the 1990s of remaining spray evaporation practices, this depiction of seep areas is almost certainly no longer accurate. However, it remains the best available map of seeps at the Site.

As is obvious from a comparison of the potentiometric surface maps for 2006 (Figure 3–29 and Figure 3–30) against those issued in pre-closure years (e.g., K-H 2004b, 2004c), the level of detail afforded by the closure network is sharply reduced relative to the network monitored in past years. Previous potentiometric surface maps were based on the data from hundreds of monitoring wells across the Site, while those for 2006 are based on many fewer locations focused on the former IA and adjacent areas of interest.

Several locations on each map are labeled as having been dry at the time of measurement, indicating areas that are unsaturated. Unsaturated areas are evident each year, but are less notable now for two reasons: First and foremost, the monitoring network in 2006 was much more streamlined than in most prior years. This results in more widely-distributed data and a lower resolution when constructing the maps, affecting both the water level contours as well as the size of dry areas. Second, many of the wells in the network are replacement wells that are better-designed and constructed than their predecessors. (Many of the previous wells did not penetrate deeply enough into the UHSU, whereas replacements typically extend well into the weathered bedrock.)

In annual reports for years prior to 2004, actual dry areas were mapped based on corresponding groups of dry wells. This is no longer feasible due to the limitations of the current network (nor is it a particularly important or meaningful objective), and only the wells themselves are shown as being dry. Despite the fact that many of the wells in the current network are improved in many ways over their predecessors, the apparent indication of wetter conditions must be considered in terms of the reduced well coverage before reaching any conclusions regarding larger-scale conditions. Wells are shown as dry if they are either dry or only contain water below the base of the screened interval (a condition that has been historically referred to at RFS as “technically dry,” because the water within the casing below the screen is stagnant and may not reflect the actual water level).

Unsaturated areas are the result of limited ground water. This condition may be caused by reduced recharge from precipitation (i.e., droughts, such as that in 2002) or reductions in the contributions from other sources. These may include such sources as dust suppression or irrigation water, unlined ditches, and water lines and other subsurface utilities that can leak water or convey ground water along their corridors. These sources were removed during Site closure and were no longer present in 2006, but their effects may continue to be expressed for several years as residual “artificial” water (i.e., from such sources as leaking water supply lines and dust suppression) moves through the system. Changes in the extent of saturation can also come about from changes in ground surface configuration (e.g., addition/removal of impervious surfaces, modification of surface water runoff), but none of the work done in 2006 would have had such an effect.

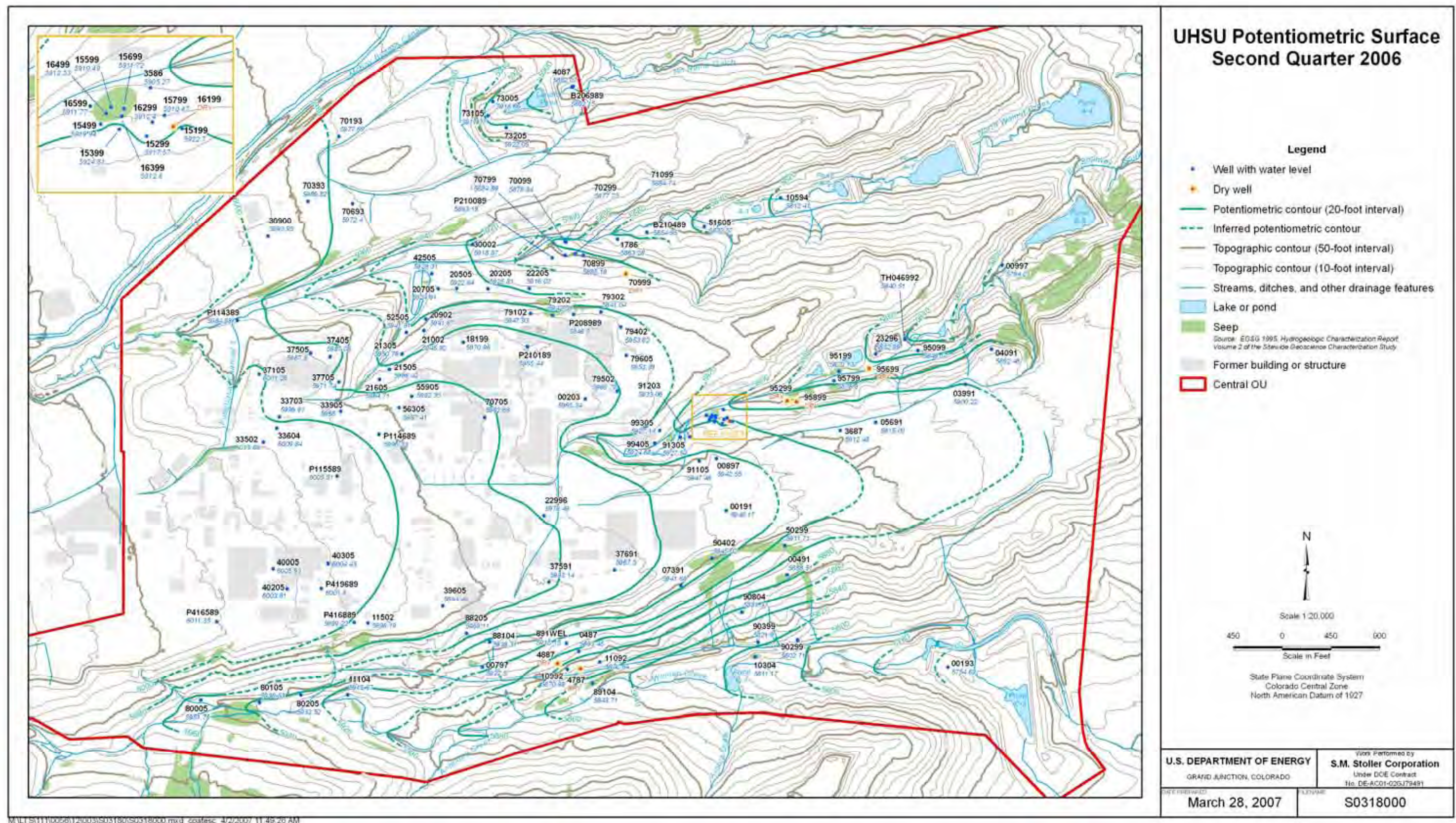


Figure 3-29. UHSU Potentiometric Contours: Second Quarter 2006

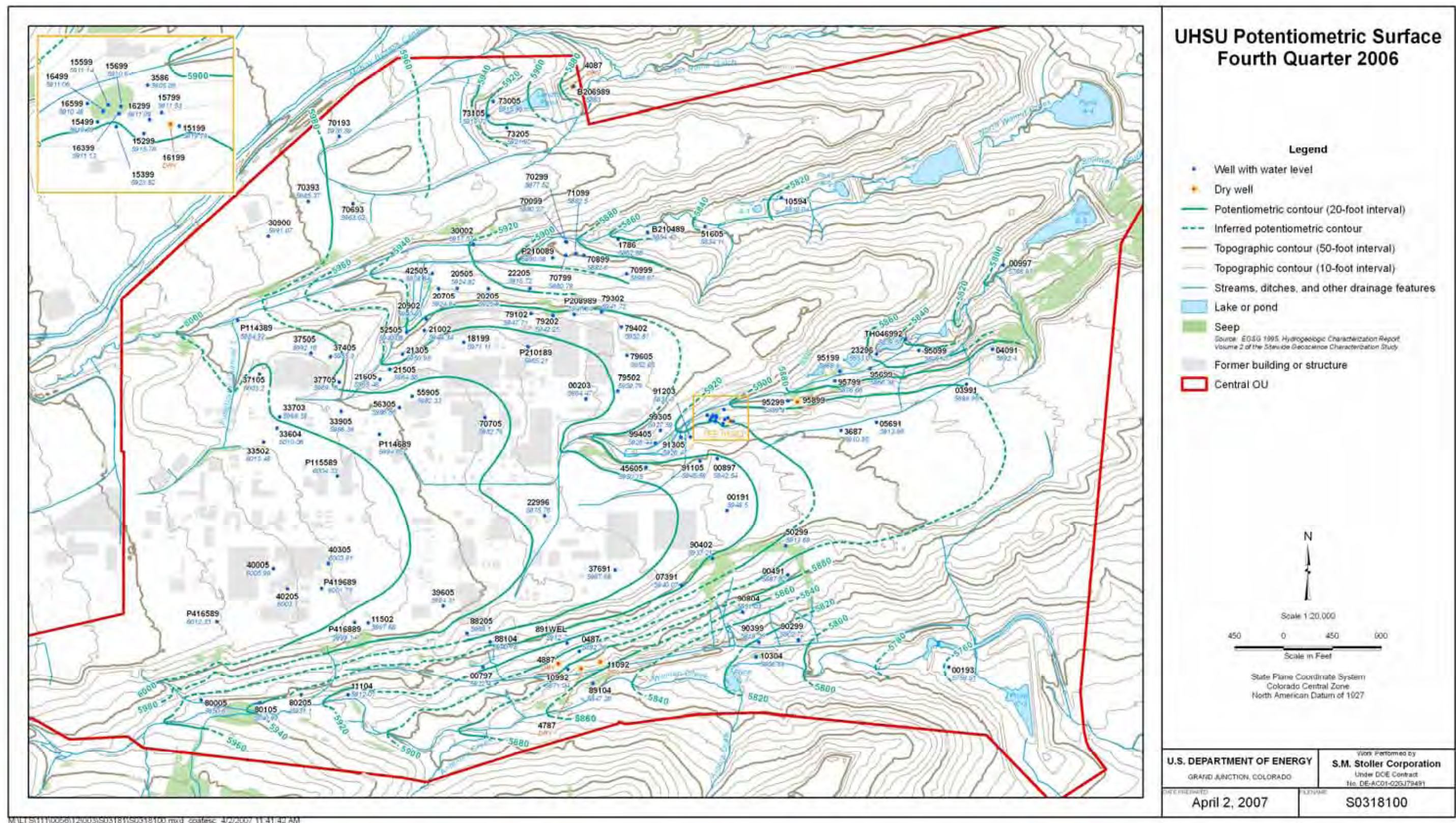


Figure 3–30. UHSU Potentiometric Contours: Fourth Quarter 2006

Precipitation in 2006 was recorded at eight locations across the Site. Table 3–8 summarizes precipitation totals for recent calendar years, and serves as evidence of the dry conditions of 2006. Note that the amount shown for 2003 incorporates March data from the Site’s 61-meter meteorology tower, which included a heated precipitation gauge that recorded precipitation from the multi-foot March 2003 snowstorm more accurately than the unheated gauges operated by the Water Programs Group. See Section 2 of this report for additional discussion of precipitation.

Table 3–8. Calendar Year Precipitation Totals at the Site

Calendar Year	Total Precipitation (inches)
1993	12.27*
1994	10.64
1995	16.49*
1996	12.36
1997	15.02*
1998	12.83*
1999	14.30
2000	12.29
2001	12.74*
2002	7.94
2003	12.35
2004	16.91
2005	11.58
2006	9.18

Notes: Total precipitation listed is an average of all precipitation gauges operating that year at the Site. In 2006, this was 8 gauges. *Value corrected from that included in 2005 Annual Report. Correction factors were 0.01 to 0.03 inches.

Unsaturated areas in 2006 are similar to those depicted in previous years, if well coverage and design are taken into account. Unsaturated areas in both the second and fourth quarters of 2006 include areas of the OU1 Plume and each of the three ground water treatment systems. These locations are typically dry; all four are controlled to a large extent by the ground water intercept trenches they are installed within or adjacent to. (At the OU1 Plume, it is the defunct French drain that is nearby.) Ground water flow directions are also generally consistent with previous years, as estimated from the potentiometric surface maps (Figure 3–29 and Figure 3–30).

Water levels are generally higher in the second quarter than the fourth quarter. This is typical, and reflects seasonal patterns. Both maps indicate the importance to ground water flow of the buried drainage south of former B371, which exerts an influence on water levels in wells in the area south and east of that facility. Where B371 used to represent a local “low” in the water table as a result of its foundation drains, the maps indicate the ground water has equilibrated in the area and it now appears to resemble ground water in the other hillsides. A similar scenario also appears to be the case in the B883/B881 area, as the edge and side of that hill appear to reflect no further effect of the now-disrupted subsurface drains. (This is also supported by hydrographs, discussed below.) Even so, it bears repeating that the well network is not designed to reveal such small-scale changes.

Hydrographs

Hydrographs were prepared and are included in Appendix A.4, and groups of hydrographs are discussed here. This section should be read while also viewing the referenced hydrographs to enable greater understanding; without the hydrographs, much of the following detailed discussion will appear meaningless.

The hydrographs combine original and replacement wells under the assumption that the corresponding data are continuous. (As additional data are collected, this may prove to be a faulty assumption at some locations, and the corresponding water level data and/or analytical data may no longer be pooled.) Differences in well construction and geology from original to replacement wells are evident on many of the hydrographs. Regarding geological differences, it is important to note that in some locations the bedrock contact is exceptionally subtle, which can lead to the selection of different depths for this contact even in geological materials that are essentially identical from the original to replacement location.

Water level data used for the hydrographs (Appendix A.3) include routine water level measurements as well as pre-sampling and specially-requested measurements. This allows a more comprehensive assessment of the hydrogeology screened by the well, as in many cases it offers information on well recharge that would be omitted if only routine water level measurements were posted. Water level elevations were calculated from the recorded depth to water and the elevation of the top of the well casing. Where a well was found to be dry, the water level posted on the hydrograph is equivalent to the elevation of the bottom of the well casing, as calculated from the measured total length of the well casing during its installation. Also posted as dry are measurements of water levels within the blank sump at the base of most wells.

Hydrographs for wells monitoring contaminant plumes in the eastern portion of the former IA and adjacent areas, including the OBP#2 Plume, Mound Site Plume, 903 Pad/Ryan's Pit Plume, and East Trenches Plume, will be discussed together due to their geographic proximity, similar hydrogeologic setting, and commingling contamination. Ground water from the OBP#2 Plume and Mound Site Plume is captured and treated by the MSPTS. In the source areas, the hydrograph for well 91105 (OBP#2) shows a fairly flat curve, while that for downgradient well 91203 shows a sharply higher water level in the spring of 2005. This was discussed in the 2005 Annual Report (DOE 2006e) and relates to pumping of water from the 700 Area across the surface just upgradient of this well. The water level in 91203 remains high throughout 2006, suggesting that the flow of ground water within the former storm drain corridor, which is routed to the MSPTS intercept trench, reduces evapotranspiration at well 91203; as is evident from the ground water quality discussions above, contaminants at that well do not support a direct contribution of ground water from the storm drain corridor, assuming ground water within that corridor reflects OBP#2 contamination. Well 00897, which monitors the Mound source area, shows ground water levels have decreased since closure but not greatly, and appear to have leveled off in 2006.

Wells 07391 and 00191 are closest to their source areas, Ryan's Pit and the 903 Pad, respectively. Hydrographs for these wells are very similar if the effects of sampling at 07391 are ignored. Following Site closure, ground water elevations at well 00191 have leveled off, but at 07391 it appears more variable. The hydrograph for well 90402, located generally between the former two wells, is also similar. Post-closure water levels are more closely related to those at

07391 than at 00191, which may relate to the mechanism causing the 903 Plume to bifurcate, with one portion flowing southeast toward Woman Creek during wetter times and the other flowing northeast to join with the East Trenches Plume. Well 00191 is located near the point at which these two lobes diverge. Farther down the hillside are wells 50299, 00491, 90804, and 90399. The hydrograph for well 90399, located adjacent to the SID, shows some similarity to the curve for well 07391. However, the hydrograph for well 50299, located closest to the top of the pediment, does not resemble any of the other curves. Located adjacent to an area that has been mapped as a seep, this well appears to receive a strong localized contribution, and therefore does not reflect the larger-scale pattern evident in other wells. This also applies at well 90804, which monitors a detachment plane beneath a slump block between well 50299 and the SID; the water level in this well is very consistent and shows no seasonal or closure-related influences. Well 00491, located near 50299, presents a water level curve that is impacted by sampling and extended dry periods. The latter portion of the curve, since the St. Patrick's Day 2003 blizzard, resembles that from wells 07391 and 00191; the 2006 data are most similar to those from well 07391. Generally speaking, these patterns indicate there are definite seasonal influences in the source areas and hillside monitoring locations except at those monitoring localized features, such as the seep near 50299 and the slump at 90804. The effects of closure on ground water elevations in this area so far appear minimal.

Wells 3687, 05691, 03991, and 04091 monitor the East Trenches Plume and are located, respectively, in the T-3 and T-4 source areas and along the distal edge of the plume. The water level curves displayed on hydrographs for wells 3687, 05691, and 03991 are very similar, reflecting the same increases and decreases in water level. There may be some seasonal component to their curves, but this is not certain because the relative high water levels occur in late summer to fall months only during odd-numbered years. Well 04091, located farther to the east, does not reflect this pattern: water levels here are very consistent and the curve is essentially flat.

The hydrographs for several wells in the vicinity of the MSPTS, most notably 15399 but also including 91203 and 15199 (and less so wells 15299, 15499, 15599, 15699, and 3586), display increasing water levels beginning in early 2005, most typically in March. This timing coincides with the routing of 700 Area water through a temporary ditch cut across the ground just upgradient of the MSPTS, and the diversion of water to the MSPTS intercept trench from the corridor formed by a storm drain, as discussed previously. This latter change continues to affect the hydrograph for well 15399 particularly strongly, with the water level in 2006 typically very close to the former top of casing. (Many of these wells were extended just prior to closure due to the addition of several feet of fill.) This condition is evident in the field as well, with the ground surface at 15399 typically moist to saturated. Conversely, well 91105, located immediately downgradient of the OBP#2 source area excavation, does not reflect this pattern, indicating it is upgradient of the impact. Also in the MSPTS area, well 15799 is just beyond the eastern end of the ground water intercept trench. This well typically has been dry since its installation, but data collected in 2006 indicate rising ground water levels here. This is likely affected, at least in part, by removal of the nearby infrastructure (North Perimeter Road, Central Ave. Ditch) and increased infiltration, but perhaps more importantly the additional water routed to the intercept trench may be sufficient to saturate this eastern end of the trench and affect water levels in nearby well 15799.

Hydrographs for wells around former B771 show the overlapping effects of several changes. Removal of the foundation drains would be expected to cause rising water levels, but removal of the water supply system and dust suppression water applied during closure activities would have an opposite effect. The net result is varied. Well 18199, located upgradient of B771 but downgradient of former IHSS 118.1, would have been strongly affected by the pumping (ground water removal) during IHSS 118.1 source removal and the application of dust suppression water during B776/777 closure. The hydrograph for this well shows a slow decrease in ground water elevations following source removal and cessation of the application of dust suppression fluids. The water level in 2006 appears to be stabilizing about two to four feet below its previous average, though that average was strongly influenced by Site activities as suggested by the hydrograph's large range. Downgradient of B771, well 20705 also shows a slightly lower average water level in 2006 than prior to closure, but the water level curve for this well lacks the larger variations evident in the upgradient well. This is also the case at well 20205, located farther to the east near former Bowman's Pond. Between these two is well 20505, which the hydrograph indicates was strongly affected by the changes brought during Site closure. Water levels at this location have been rebounding since spring 2005; this may be related to removal of the storm and foundation drains that previously either emptied to the Bowman's Pond area or were routed to the west and north via subsurface drains.

Hydrographs for wells monitoring the former B371/374 complex (37105, 37405, 37505, and 37705, plus more distal P114389) each shows a very different pattern from the others. Ground water around this facility was formerly controlled very strongly by a pair of foundation drains, one around the building's basement and one around its sub-basement. The most consistent element in hydrographs from the first three wells listed—located on the west and north of B371/374—is a drop in water levels immediately following Site closure. This would relate to ground water filling the previously-dry subsurface following disruption of the foundation drains. Of these three wells, it is least obvious at 37105, consistent with its location upgradient of the complex, and most strongly indicated by the water levels in well 37505, located downgradient of B371. The amount of this decline ranges from about 4 feet at well 37105 to about 25 feet at well 37505. The hydrograph for well 37405 is complicated in that it indicates a broader, two-step decrease similar to that at upgradient well 37105. Water levels in all three wells rebounded. Well 37705, located near where the foundation drains for the two subsurface portions of the buildings came together, shows an increase in water level following closure, and then a decrease to a level more consistent with pre-closure conditions. However, the original well, 37701, was located almost 200 feet northeast of replacement well 37705, which may require their respective data pools to be considered separately. This topic will continue to be assessed as more analytical and hydrological data are collected. Finally, well P114389, located northwest of the B371/374 complex and at the mouth of FC-1, presents a hydrograph that shows very little change from pre-closure water levels. A slight decline is present at a time coinciding with Site closure, but otherwise the water levels are consistent with earlier data.

Ground water around the unnamed drainage between former B771 and B371 is monitored by several wells. Well 20902 is located adjacent to a former B771 foundation drain outfall. The hydrograph for this well indicates decreasing water levels since Site closure and the cessation of dust suppression activities. Conversely, nearby well 21002 shows little change over the years, because it is not as near or strongly influenced by foundation drains or dust suppression and closure activities. Other wells in this area include 21305, 21505, 21605, and 33905. Each of these locations shows a drop in water levels correlating with the timing of Site closure, followed

by either a rebound (partial, as in the case of wells 21305 and especially 21605, or complete, as in the case of 21505) or static conditions (well 33905). The seep at well 21605 and the subsurface conditions it represents probably influence the three rebounding water levels, but well 33905 is farther upgradient and is unaffected by these localized conditions.

Well 33905 also monitors the northeast end of the buried drainage present south of B371, which is also monitored by wells 33502, 33604, and 33703. (These three wells monitor the vinyl chloride plume.) Wells 33502 and 33604 maintain very stable water levels, showing little or no influence by Site closure. Water levels in wells 33703 and 33905 show similar patterns through closure, then the former well begins a gradual rebound while the latter, as noted above, remains fairly stable.

In the central portion of the former IA, hydrographs for wells P114689 and P115589 both indicate water levels that are not dramatically affected by Site closure. Water levels at the former well, located between former B551 Warehouse and B559, are within their historic range. The water level at P115589, located on the western edge of the former Warehouse, shows a slight decline in water levels that may have begun as early as 2003. Wells 55905 and 56305 both monitor former B559, and also show minimal effects from closure, with 2006 water levels falling generally within their former ranges. However, well 70705, located on the east side of former B707, shows a significant increase in water levels that may be related to the disruption of the foundation drain at that building.

Farther south, at former B444, hydrographs from wells 40005, 40205, and 40305 show smooth water level curves with little or no response to Site closure. The foundation drain for this complex was not extensive, and its disruption appears to have had little effect on water levels. In addition, the predecessor wells all produced ground water readily, suggesting the drain system did not have a very strong effect on water levels prior to closure. The hydrograph for nearby well P419689, however, does reflect a drop in water levels coinciding with closure—and immediately following an increase that is likely related to the dust suppression water applied during demolition and closure of B444. Hydrographs for wells 11502 and P416889, both located farther southeast of B444, also show an increase that may be related to dust suppression activities, but the decline in water levels following closure is not indicated here. Possible factors in the declining water levels at well P419689 include removal of two small drainages near the well prior to closure, and the removal of the subsurface water lines that were present here.

Hydrographs for wells in the former 800 Area clearly show the impacts of closure on ground water levels in this area. The predecessor to well 88205 (well 5187) used to be in a parking lot on the south side of B881, and was strongly affected by the foundation drain system. Following disruption of that system, water levels at this location have risen dramatically—an increase of nearly 20 feet is apparent on the hydrograph. Nearby well 88104 also shows a significant increase of just over 10 feet. This latter well is separated from the original well by over 100 feet, but the pattern is probably representative of this area. On the pediment surface in the 800 Area, well 39605 is closest to former B881. The hydrograph for this well appears to show closure exerted little or no effect on ground water elevations in this area. Its predecessor, well 39691, was often dry, a condition which was previously thought to be due to the presence of the B881 foundation drain a short distance downgradient (east) of the well. However, the deeper replacement well suggests these conditions may have been natural and water levels here were not strongly affected by the drain. The lack of a strong influence on water levels at downgradient

well 00797 is also apparent in the hydrograph from that well; a similar apparent lack of closure-related change is shown at 881 Hillside wells 891WEL (which is represented by few data), 0487, 4787, 4887, 10992, and 11092. In the 891 Yard area, well 37591, located near the former B891 water treatment facility, shows a water level drop of just over 10 feet since closure. This well was also located adjacent to a water line, which may have influenced water levels here. Farther east, well 37691 at the south end of the former 904 Pad shows a water level increase of about two feet since closure, possibly related to the removal of the impermeable surfaces represented by the many paved surfaces that previously diverted precipitation and limited local recharge.

The hydrographs indicate that water levels in the source area of the SPP are relatively stable. Downgradient to the north, the water level in well 22205 appears to be leveling off at a lower elevation than prior to closure, possibly affected by the dry climate in 2006. Conversely, ground water in well P210089 is leveling off higher than its pre-closure elevation, possibly because the drainage that used to transport surface water adjacent to the well is gone, allowing this water to infiltrate. Alluvial well 70099 and weathered bedrock well 70299 show little change with respect to earlier data. The hydrograph for well 70299 is remarkably uniform, while that for 70099 may indicate a slight increase in water levels.

At former B991, hydrographs for wells 99305 and 99405 suggest ground water in this area is also stabilizing. Water level curves at both wells appear to be influenced by sampling. Ground water levels at well 99305 (located near the northeast edge of the former building) show little impact from Site closure, and are fairly steady at what would have been near the top of the range for this location prior to closure. Ground water at well 99405, which was located in what was the loading dock area on the southeast corner of the building, has been rising since approximately June 2005. This coincides with construction of the future FC-4 wetland area; not surprisingly, the constructed wetland area adjacent to this well has caused its water level to rise. The 2-inch well diameters of 99305 and 99405 show reduced effects of sampling, as compared to the original one-inch-diameter wells.

The hydrograph for Evaluation well 30900, located in the PU&D Yard source area, shows an extremely well-developed, cyclical recharge pattern. Water levels are higher in late second quarter—June—of each year, with the March 2003 blizzard contributing to the rise that year. But the increase in 2006 is very muted, which is consistent with the very dry conditions that spring and summer. This pattern is also evident on the hydrograph for well 70393, located nearby on the upgradient (west) side of the PLF.

Wells monitoring drainages display interesting patterns. Ground water in the North Walnut Creek drainage is monitored by, from upgradient to downgradient, wells P114389, 52505, 42505, 30002, 1786, B210489, 51605, 10594, and 41691 (the last of which is at the Walnut Creek/Indiana Street intersection). Similarities can be seen among the hydrographs for many of these wells. The most upstream of these, P114389, 52505, and 42505, show very similar patterns with clear seasonal influences; the lattermost well is represented by minimal data and slow initial ground water production. Well 30002 presents a different water level curve that appears to be affected seasonally but also by sampling and the dust suppression measures employed during removal of the North Perimeter Road and associated paved areas, including former Portal 3. Since closure, water levels in this well have decreased smoothly, and appear to be stabilizing within its former (pre-dust suppression) range. Skipping wells whose water levels are strongly affected by the SPPTS, the next well downgradient is 1786. The water level curves at 1786 and

next-downgradient well B210489 are similar, and appear more similar to the wells farther upgradient than to nearer well 30002. This may be expected, since well 30002 was isolated from the bulk of the surface water flow prior to closure, as it was routed through culverts from former Portal 3 to just west of well 1786. In addition, well 30002 is influenced by ground water discharging to the North Walnut Creek drainage from the pediment to the north (which hosts the PU&D Yard and PLF) while the others reflect ground water discharging to the drainage from the south (the location of the IA). The hydrograph for well 51605, located near the inlet to Pond A-1, shows the effects of seasonal influences, sampling, and slow initial ground water production in the replacement well (51605; the original well was 1386). The water level curve here is much like the other upgradient wells except 30002, and is also very similar to that for next-downgradient well 10594, located between Ponds A-1 and A-2. The hydrograph for well 10594 displays limited data, and also appears affected by sampling, but the overall behavior is very similar to that at well 51605 on the upstream side of Pond A-1. This suggests that, as would be expected, the water levels in both wells adjacent to Pond A-1 may be strongly influenced by the pond. Finally, well 41691 shows the recharge to ground water downgradient of the terminal ponds that has been provided by pond discharges. Since the last discharge in May 2005, the hydrograph for well 41691 shows a steady decline in water levels.

The South Walnut Creek drainage is monitored by, from upgradient to downgradient, wells 99405, 91305, 23296, TH046992, 00997, and 41691. (As with the discussion on North Walnut Creek, wells most strongly influenced by the ground water intercept trench—in South Walnut Creek, it is the ETPTS—are not included in this discussion.) Unlike the hydrographs for wells monitoring North Walnut Creek, there is not much similarity in those monitoring South Walnut Creek. The most upgradient well, 99405, is strongly affected through mid-2005 by closure of former B991 and construction of FC-4. Nearby well 91305 is slightly less than 60 feet southeast of the location of original well 2187, which was adjacent to a wetland just east of B991. The hydrograph for this well shows a very flat curve, with a slight increase in water level in the replacement well compared to the original well. The flatness of this curve is completely dissimilar to the curve for well 99405, which reflects adjacent closure activities. Farther down the South Walnut Creek drainage, the hydrograph for well 23296, located between Ponds B-2 and B-3, is also fairly uniform but appears to show seasonal recharge, the effects of sampling, and as expected, the adjacent ponds. Well TH046992, installed as a dam piezometer for the Pond B-3 dam, has a very flat curve similar to that for well 91305. Although Pond B-3 was dry or nearly so for much of 2006, the hydrograph for well TH046992 reflects only a very small decline in water levels. The hydrographs for well 00997, located at the inlet to Pond B-5, and 41691, located at Walnut Creek and Indiana Street, are very similar in that they reflect pond discharge and a decreasing water level since closure.

The Woman Creek drainage is monitored by, from upgradient to downgradient, wells 80005, 80105, 80205, 11104, 89104, 10304, 00193, and 10394. Only the last of these, which is located at the Woman Creek and Indiana Street intersection, has plentiful water level data. More data will be needed from the other wells to enable clear patterns to be distinguished. The first three of these are downgradient of the OLF, and monitor ground water entering the drainage from the OLF and pediment to the north. As such, their hydrographs are strongly influenced by water moving within the constructed buttress at the base of the OLF. The hydrographs for these three wells are all fairly smooth, but also show they monitor different ground water regimes. The curve for well 80005 is very uniform, while that for 80105 shows a period of lower water levels following Site closure and that for 80205 shows an increase in water levels following closure.

Each well is, therefore, influenced somewhat by different ground water sources. Farther downgradient, well 11104 presents a hydrograph with a decrease in water levels coinciding with Site closure, followed by a rapid rebound to pre-closure levels. With additional data, the hydrograph for this well may reveal the expected strong seasonal component. Ground water monitored by well 89104 appears to have been rebounding since this well was first monitored in early 2005. The hydrograph for well 10304, located just east of Pond C-1, is most similar to that for well 11104. Well 00193 presents a water level curve that shows a steep drop coinciding with Site closure, followed by a steady rebound through 2006. The hydrograph for Boundary well 10394 shows a very strong seasonal pattern, with the well either dry or nearly so during dry months.

3.3.4.2 Ground Water Flow Characteristics

Ground water flow directions and velocities in 2006 are generally consistent with those reported in 2005. As previously noted, the main changes following Site closure are seen at B371, where disruption of the foundation drain system has caused this area to no longer act as a ground water sink. Water levels in this area appear to have equilibrated across the B371 pediment, although they do and will continue to reflect the presence of the buried drainage to the south (Figure 3–29 and Figure 3–30). The disruption of foundation drains will also influence flow paths at B771 and B883/881, for example.

Flow directions, water level data, geological information, and completed well designs and locations support the selection of several well pairs for the calculation of linear ground water flow velocities, also referred to as seepage velocities. Using the potentiometric surface maps, a pair of wells is potentially useful if a line drawn between them is perpendicular (or nearly so) to the potentiometric contour lines between the two wells, and there are no intervening drainages or artificial ground water control structures such as the ground water intercept trenches that are a component of each of the treatment systems.

Well pairs selected for use in this Report are the same as those selected in 2005 plus one pair at the OLF (which is discussed at greater length in Section 3.4).

The seepage velocity (v) may be calculated using the Darcy equation:

$$v = \left(\frac{K}{n} \right) \left(\frac{dh}{dl} \right)$$

where

K = hydraulic conductivity

n = effective porosity

dh/dl = hydraulic gradient.

This calculation is most sensitive to the hydraulic gradient and value of K used, because for all calculations of v in this report a consistent porosity of 0.1 is used. This is consistent with previous Annual RFCA Groundwater Monitoring Reports.

The hydraulic gradient was calculated from water level measurements performed in the 2nd and 4th quarters of 2006. Results of this calculation typically differ slightly when using data from one quarter vs. that from another, but the differences are typically not large.

Calculated seepage velocities are only useful as estimates. These velocities are most often used to estimate the travel time of conservative (non-reactive) constituents. Reactive constituents will tend to migrate more slowly than the calculated velocity. It is important to note that these calculated velocities do not take into account properties such as sorption and chemical reactions (e.g., precipitation, biodegradation, volatilization) that can strongly influence the migration rate of ground water contaminants.

For each well pair, the hydraulic conductivity, K, selected for this calculation was based on the predominant lithologic unit comprising the flow path between the two wells. This is based on the core logs for the respective wells and the published geology (EG&G 1995a), plus information from the hydrographs (i.e., whether ground water is typically restricted to the bedrock or extends into surficial materials). If more than one lithology was represented between the wells, an average K was calculated from that for each of the two lithologies. Similarly, if the water was present within different geologic materials from one season to another, these differences were accounted for via the use of corresponding hydraulic conductivities. K values used for these calculations are from EG&G (1995b), Table G-2, with subsequently modified values for Rocky Flats Alluvium (Qrf) and valley-fill alluvium (RMRS 2000; Safe Sites 2001, 2002).

One factor that cannot be accounted for without additional aquifer test data, and which may cause significant error in estimated seepage velocities, is the presence of artificial fill in many portions of the former IA. The K for Qrf is used because the source of the fill was typically various areas of the Rocky Flats Alluvium. However, it is unlikely that the backfilled alluvium is as well-packed as the original deposits, resulting in a higher effective porosity and K. Where well pairs cross former buildings that were backfilled with concrete rubble and alluvium, the effective porosity and K values will be higher still. For this report, well pairs crossing areas of sufficiently thick backfill deposits use the K for Qrf rather than that for the original lithology, under the assumption that the entire area of backfill/regrading has a hydraulic conductivity closer to that of the Rocky Flats Alluvium than to a lower-permeability unit.

An example well pair may serve to illustrate some of the related difficulties. Well 18199 is located between former B776 and B771. It screens Qrf and sandstone of the Arapahoe Formation (the "Number One Sandstone;" EG&G 1995a). Ground water in this area previously flowed toward the west as a result of the B771 foundation drain system. Following disruption of this drain, ground water flow will be more northerly, potentially through the rubble- and alluvium-backfilled subsurface remnants of B771. Well 20505 was selected as the downgradient well in this well pair. This well screens artificial fill, clays, claystone, and silty claystone. The transect from 18199 to 20505 is mostly occupied by the artificial fill of the B771 closure, and that fill is essentially reworked alluvium. Therefore, an average hydraulic conductivity of the Arapahoe Formation No. 1 Sandstone and Qrf is used to calculate the seepage velocity between this well pair.

As noted above, these calculated velocities are based in part on data displayed on the hydrographs: where water is shown above the bedrock contact, hydraulic conductivities for the unconsolidated surficial material (e.g., Qrf or Qc) are selected for this calculation. If the hydrographs show water is typically restricted to the bedrock, the K value for the generalized bedrock type is selected. Note that the extreme variability of bedrock lithologies (i.e., from

claystone to silty claystone to clayey siltstone to siltstone) is often reflected in core from the screened interval of a given well, but a single K value is selected to represent the well.

Table 3–9 presents the results of the calculation of seepage velocities. Refer to Figure 3–1 for the respective locations of the wells. Estimated velocities range from 17 feet per year (from well P210189 to 79102 in the SEP area) to 600 feet per year (from well 18199 to 20505 in the B771 area). The time to traverse the distance between each well in a well pair ranges from about 10 months (from well 18199 to 20505) to 74 years (from well 40305 at B444 to well 22996 at B886). These velocities are comparable to those calculated prior to Site closure (e.g., see K-H 2004b).

Table 3–9. Calculated Flow Velocities for 2006

Well pair	Area	2006 quarter	Geological unit	WL elevation, well 1	WL elevation, well 2	dh (ft)	dl (ft)	dh/dl (hydraulic gradient)	K (cm/s)	v (ft/yr)	Time to traverse transect (yrs)
P115589-P114689	North IA	2	Qrf	6005.51	5996.33	9.18	550.14	0.017	4.18E-04	72.17	7.62
P115589-P114689	North IA	4	Qrf	6004.33	5994.85	9.48	550.14	0.017	4.18E-04	74.53	7.38
P114689-56305	North IA/B559	2	Qrf	5996.33	5987.41	8.92	304.74	0.029	4.18E-04	126.59	2.41
P114689-56305	North IA/B559	4	Qrf	5994.85	5986.86	7.99	304.74	0.026	4.18E-04	113.39	2.69
56305-21605	B559	2	Qrf/Qc	5987.41	5964.71	22.7	319.61	0.071	2.56E-04	187.86	1.70
56305-21605	B559	4	Qrf/Qc	5986.86	5965.48	21.38	319.61	0.067	2.56E-04	176.94	1.81
18199-20505	B771	2	Qrf/KaNo.1ss	5970.96	5922.84	48.12	500.43	0.096	6.03E-04	599.92	0.83
18199-20505	B771	4	Qrf/KaNo.1ss	5971.11	5924.92	46.19	500.43	0.092	6.03E-04	575.85	0.87
P416589-80105	OLF	2	Qrf/KaKlclst	6011.35	5938.53	72.82	846.63	0.086	2.09E-04	186.38	4.54
P416589-80105	OLF	4	Qrf	6012.33	5940.99	71.34	846.63	0.084	4.18E-04	364.42	2.32
40305-39605	South IA	2	Qrf/KaKlslt	6004.43	5994.49	9.94	1126.39	0.009	2.23E-04	20.40	55.22
40305-39605	South IA	4	Qrf/KaKlslt	6003.91	5994.31	9.6	1126.39	0.009	2.23E-04	19.70	57.18
40005-P419689	South IA	2	Qrf	6005.93	6001.8	4.13	478.87	0.009	4.18E-04	37.30	12.84
40005-P419689	South IA	4	Qrf	6005.99	6001.75	4.24	478.87	0.009	4.18E-04	38.29	12.51
P419689-11502	South IA	2	Qrf	6001.8	5998.19	3.61	535.27	0.007	4.18E-04	29.17	18.35
P419689-11502	South IA	4	Qrf	6001.75	5997.66	4.09	535.27	0.008	4.18E-04	33.05	16.20
40305-22996	South IA/800 Area	2	Qrf/KaKlclst *	6004.43	5978.49	25.94	2037.05	0.013	2.09E-04	27.59	73.82
40305-22996	South IA/800 Area	4	Qrf/KaKlclst *	6003.91	5975.76	28.15	2037.05	0.014	2.09E-04	29.95	68.03
88205-00797	881 Hillside	2	Qrf/Qc	5969.11	5922.5	46.61	343.12	0.136	2.56E-04	359.31	0.95
88205-00797	881 Hillside	4	Qrf/Qc	5969.1	5922.4	46.7	343.12	0.136	2.56E-04	360.00	0.95
00191-00491	903 Pad-Lip	2	Qrf/KaKlclst	5948.17	5888.51	59.66	816.98	0.073	2.09E-04	158.24	5.16
00191-00491	903 Pad-Lip	4	Qrf/KaKlclst	5948.5	5887.82	60.68	816.98	0.074	2.09E-04	160.95	5.08
00491-90399	903 Hillside	2	Qc/KaKlclst	5888.51	5821.80	66.71	676.30	0.099	4.71E-05	48.06	14.07

Table 3–9 (continued). Calculated Flow Velocities for 2006

Well pair	Area	2006 quarter	Geological unit	WL elevation, well 1	WL elevation, well 2	dh (ft)	dl (ft)	dh/dl (hydraulic gradient)	K (cm/s)	v (ft/yr)	Time to traverse transect (yrs)
00491-90399	903 Hillside	4	Qc/KaKlclst	5887.82	5819.26	68.56	676.30	0.101	4.71E-05	49.39	13.69
07391-10304	Ryan's Pit/ Woman Ck.	2	Qc	5941.68	5811.17	130.51	948.74	0.138	9.33E-05	132.79	7.14
07391-10304	Ryan's Pit/ Woman Ck.	4	Qc/KaKlclst	5940.07	5808.69	131.38	948.74	0.138	4.71E-05	67.47	14.06
91105-91203	Oil Burn Pit #2	2	Qrf/KaKlsilt	5947.48	5933.06	14.42	242.17	0.060	2.23E-04	137.63	1.76
91105-91203	Oil Burn Pit #2	4	Qrf/KaKlsilt	5945.59	5931.3	14.29	242.17	0.059	2.23E-04	136.39	1.78
91105-15499	Oil Burn Pit #2	2	Qrf/Qc	5947.48	5919.94	27.54	392.19	0.070	2.56E-04	185.74	2.11
91105-15499	Oil Burn Pit #2	4	Qrf/Qc	5945.59	5919.69	25.9	392.19	0.066	2.56E-04	174.68	2.25
91105-15399	Oil Burn Pit #2	2	Qrf/Qc	5947.48	5924.81	22.67	394.09	0.058	2.56E-04	152.16	2.59
91105-15399	Oil Burn Pit #2	4	Qrf/Qc	5945.59	5923.52	22.07	394.09	0.056	2.56E-04	148.13	2.66
00897-15499	Mound	2	KaKlsilt/Qc	5942.55	5919.94	22.61	366.17	0.062	6.11E-05	39.00	9.39
00897-15499	Mound	4	KaKlsilt/Qc	5942.54	5919.69	22.85	366.17	0.062	6.11E-05	39.42	9.29
00897-15399	Mound	2	KaKlsilt/Qc	5942.55	5924.81	17.74	347.49	0.051	6.11E-05	32.25	10.78
00897-15399	Mound	4	KaKlsilt/Qc	5942.54	5923.52	19.02	347.49	0.055	6.11E-05	34.57	10.05
P210189-79102	SEPs	2	KaKlsilt	5965.44	5947.93	17.51	301.98	0.058	2.88E-05	17.28	17.48
P210189-79102	SEPs	4	KaKlsilt	5965.21	5947.71	17.5	301.98	0.058	2.88E-05	17.27	17.49
79102-22205	North of SEPs	2	KaKlsilt	5947.93	5916.02	31.91	235.62	0.135	2.88E-05	40.36	5.84
79102-22205	North of SEPs	4	KaKlsilt	5947.71	5915.72	31.99	235.62	0.136	2.88E-05	40.46	5.82
79502-99305	SEPs/B991	2	KaKlsilt/Qrf	5960.79	5927.14	33.65	532.37	0.063	2.23E-04	146.10	3.64
79502-99305	SEPs/B991	4	KaKlsilt/Qrf	5959.79	5927.59	32.2	532.37	0.060	2.23E-04	139.80	3.81
70393-70693	PU&D/PLF	2	Qrf	5986.82	5972.4	14.42	410.48	0.035	4.18E-04	151.93	2.70
70393-70693	PU&D/PLF	4	Qrf	5985.37	5963.02	22.35	410.48	0.054	4.18E-04	235.48	1.74
30900-30002	PU&D/ N. Walnut Ck.	2	Qrf/KaKlclst	5993.95	5918.87	75.08	1890.74	0.040	2.09E-04	86.05	21.97
30900-30002	PU&D/ N. Walnut Ck.	4	Qrf/KaKlclst	5991.07	5917.57	73.5	1890.74	0.039	2.09E-04	84.24	22.45

Notes:

WL = water level; dh (ft) = difference in height, in feet; dl (ft) = distance between wells, in feet; cm/s = centimeters per second; v (ft/yr) = velocity in feet per year; yrs = years.

Qrf = Rocky Flats Alluvium; Qc = colluvium; KaNo.1ss = Arapahoe Formation "No. 1 Sandstone"; KaKlclst = undifferentiated Arapahoe/Laramie Formation claystone; KaKlsilt = undifferentiated Arapahoe/Laramie Formation siltstone.

*Bedrock lithology estimated due to incomplete core log for well 22996.

Flow across the former IA is calculated for several well pairs (Table 3–9). The travel time from well P115589 to P114689 and then to 56399 and into the drainage at 21605 can be estimated by summing the individual calculated travel times. The result is approximately 11 to 12 years. In the southern IA, flow from well 40305 to 39605, or from 40305 to 22996, is calculated to take approximately 55 or 70 years, respectively.

Flow across the former B444 is estimated using wells 40005 and P419689. The travel time here is estimated at 12.5 to 13 years. This is based on the K for Rocky Flats Alluvium. However, although the former building was backfilled with that material, this is an example of the scenario discussed above in which the backfill would almost certainly have a significantly higher K. If the value of K is an order of magnitude higher, the seepage velocity increases from about 37 feet per year to nearly 360 feet per year, and the travel time is reduced from almost 13 years to less than 1.5 years. This illustrates the sensitivity of this calculating to the value of K used, and also highlights the uncertainty when calculating travel times across areas of artificial fill (such as B444 now represents). Refer to Section 3.3.3.2 and Figure 3–21 for information and discussion of the VOCs in ground water in this area.

Table 3–9 includes calculated travel times for several alternate flow paths. Ground water from the OBP#2 source area, as monitored by well 91105, is captured and treated at the MSPTS, and therefore well pairs 91105-15399 and 91105-15499 are included. Both are included because ground water elevations vary by 4 to 5 feet between the two downgradient wells, affecting the calculated gradient. Even so, the difference is only 6 months or less in total calculated travel time from the source-area well to the MSPTS well, ranging from just over 2 years to just over 2 ½ years. Alternatively, in case the OBP#2 ground water flow path does have more of a westerly component, well pair 91105-91203 is included; the calculated travel time between the wells in this pair is slightly less than 2 years. As discussed in the section on the OBP#2 Plume (Section 3.3.3.4), there have been so many changes in this area that their effects on contaminant transport are still unclear, and more data will be needed before conclusions can be drawn. However, in this specific case (91105-91203) the calculated travel times are probably not applicable, because ground water is presumably captured by the preferential pathway formed by the corridor remaining from the 72-inch storm drain. This feature has been tied into the MSPTS ground water intercept trench, and contaminants measured in MSPTS influent as well as the volume of influent (see Section 3.3.2.1) have increased significantly since that corridor was redirected into the trench. This suggests that OBP#2 water is being transported by this feature. Such a conclusion is also supported by flow data presented in the 2005 report (DOE 2006e).

Alternate paths are also provided for Mound plume well pairs 00897-15399 and 00897-15499, with a difference of up to 1.5 years in calculated travel time. For the former path, the calculated travel time is 10 to 11 years; for the latter path, the travel time is just over 9 years. In either case, this travel time suggests the effects of remediation of the Mound source area (which was completed in 1997) may soon be apparent in Mound Plume ground water that is captured and treated by the MSPTS. However, the addition of OBP#2 ground water could mask this. Most importantly, given that VOC concentrations in samples from source-area well 00897 are not rapidly decreasing, it may be many years before the effects of the Mound remediation is evident at the MSPTS.

Seepage velocities were also calculated for monitoring wells in the 903 Pad/Ryan's Pit Plume area. Two flow paths were selected, based in part on previous work (K-H 2004a). One, from Evaluation wells 00191 to 00491, may not be realistic, as ground water from well 00191 more likely migrates northeastward toward the East Trenches Plume as suggested by the contaminant distributions (Section 3.3.3.1). Even so, as a well more directly upgradient from 00491 but still near the 903 Pad VOC source area would have a similar water level elevation to that of 00191, this calculation is still useful. The results of this calculated travel time, approximately five years,

suggest that the effects of the 903 Pad and Lip remediation and HRC applications will not be reflected in ground water samples collected from well 00491 for at least several years. The second leg of this flow path, down the hillside from Evaluation well 00491 to Sentinel well 90399 at the SID, is calculated to take approximately 14 years. Therefore, effects of the remediation and HRC application would probably not be apparent in VOC data from the latter well for at least 20 years, even under the most conservative flow conditions (i.e., ignoring the effects of contaminant retardation).

The second flow path selected in this area includes Ryan's Pit source-area Evaluation well 07391 and Woman Creek AOC well 10304. The flow between these was considered to be within the hillslope colluvium during the second quarter and within the bedrock for part of the travel path during the fourth quarter of 2006, based on the hydrograph for well 07391. These calculated seepage velocities are approximately 7 years to 14 years, respectively. Because Ryan's Pit VOCs are not detected at well 10304, currently no effect from the HRC application near well 07391 is anticipated at the AOC well.

Table 3–9 indicates that if the 18199-20505 pathway is appropriate, the latter well could have begun to report detections of carbon tetrachloride and chloroform in 2006. This was not the case. This pathway is reasonable, but given the intervening presence of a disrupted foundation drain and its corridor, the backfilled building, and backfilled/disrupted subsurface utility corridors on the north side of former B771, the ground water may be diverted in another direction. Note that in 2006 none of these downgradient wells—not 20205, 20505, or 20705—reported detections of carbon tetrachloride or chloroform, the most notable contaminants from IHSS 118.1.

In the former SEP area, travel times were calculated for wells monitoring the VOC plume here as well as for a potential southeastern route for nitrate contamination. Well P210189 reports the highest concentrations of VOCs in this area; the calculated travel time from it to well 79102 is about 17.5 years. The latter well has also reported elevated concentrations of VOCs; the calculated travel time for ground water to flow from this well to well 22205 is approximately 6 years. Well 22205 has yet to report consistent detections of VOCs, despite the fact that well 79102 has produced samples with elevated concentrations of VOCs since its installation in 2002 and it is fairly safe to assume ground water at 79102's location contained VOCs for at least several years before the well was installed. This is empirical evidence against the common practice of assuming a calculated travel time for ground water applies equally to VOCs. The calculated travel time across a potential southeastern flow path, from well 79502 to 99305, is nearly 4 years. Because nitrate contamination is not evident at well 99305, such a flow path is probably unlikely.

Also arguing against the liberal application of calculated ground water travel times to contaminants is the calculated travel time from PU&D source area well 30900 to well 30002 in North Walnut Creek. This travel time is estimated at approximately 22 years. However, the PU&D Yard Plume source has probably been present for at least 20 or 30 years, which may be indicative of the retardation that affects VOCs compared to pure ground water.

3.4 Ground Water Monitoring at the Present Landfill and Original Landfill in 2006

This section presents the evaluation of the CY 2006 ground water quality data for the PLF, previously known as OU7; and the OLF, previously OU5.

3.4.1 Present Landfill

The PLF is located in the former Buffer Zone (BZ) just north of the former IA. It served as a solid waste disposal facility for the RFP/RFETS and has not been operational since 1998. Including the Landfill Pond, it occupies approximately 44 acres at the western end of the No Name Gulch drainage. The PLF underwent RCRA closure and an engineered RCRA-compliant cover was constructed as a part of the PLF and Site closure. These activities were performed and completed during 2005. Since that time, routine monitoring and maintenance have been the focus at the PLF. Refer to K-H (2004) for details on closure of the PLF.

The Annual RCRA Groundwater Monitoring Reports for RFETS (DOE, 1990, 1991a, 1992, 1993, 1994, 1995, 1996) describe ground water data for 1989 through 1995 at the PLF. The Phase I RCRA Facility Investigation/Remedial Investigation Work Plan for Operable Unit 7: Present Sanitary Landfill (DOE 1991b) presents additional information. Subsequent ground water monitoring activities were conducted under RFCA during CY 1996, 1997, 1998, and 1999, and are presented in annual Present Sanitary Landfill Groundwater Monitoring Reports (DOE 1998, 1999a, 2000). From 1999 through 2003, the annual data assessment for the PLF has been included in the Annual RFCA Groundwater Monitoring Reports (Safe Sites 2001, 2002; K-H 2004c). The 2004 information is presented in the Fourth Quarter RFCA Groundwater Monitoring Report for Calendar Year 2004 (URS 2005), and that for 2005 is in the 2005 Annual Report (DOE 2006e). Additional background information regarding the PLF is presented in the OLF Interim Measure/Interim Remedial Action (IM/IRA) for IHSS 114 and RCRA Closure of the PLF (DOE 2004).

Ground water monitoring requirements at the PLF were consistent over the course of the year, and are outlined in the 2006 IMP (DOE 2006c). Figure 3–1 displays the ground water monitoring network at the PLF. Monitoring performed in 2006 is summarized in Table 3–10.

The RCRA monitoring network at the PLF comprises three upgradient and three downgradient wells. A year of quarterly analytical data (i.e., four sets of quarterly samples) are required to determine the baseline, and the same quantity of data are needed to perform the statistical analyses. This 2006 report represents the first annual report to present these analyses for the post-closure network, due to these data requirements.

Table 3–10. RCRA Ground Water Sampling Performed in 2006 at the PLF

Well	Location	Q1	Q2	Q3	Q4
70193	Upgradient	V, M	V, M	V, M	V, M
70393	Upgradient	V, M	V, M	V, M	V, M
70693	Upgradient	V, M	V, M	V, M	V, M
73005	Downgradient	V, M	V, M	D	V, M
73105	Downgradient	V, M	V, M	V, M	V, M
73205	Downgradient	V, M	V, M	V, M	V, M

Notes:

Q = quarter.

V = VOCs, M = metals (which includes U), D = dry or insufficient water to complete the analytes listed.

Only RCRA wells supporting the PLF are listed; other wells in the area (such as Sentinel and Evaluation wells) are omitted because they are not a part of the RCRA monitoring network.

Statistical evaluation of the analytical data from the PLF was performed using all non-rejected data for upgradient and downgradient RCRA wells. An interwell comparison was made (i.e., comparing upgradient wells against downgradient wells) in accordance with the PLF M&M Plan (DOE 2006b), using the Analysis of Variance (ANOVA) procedure as run using the Sanitas™ software package. Non-parametric ANOVA was required for most analytes, but a few were represented by normally-distributed data and were analyzed using parametric ANOVA. U data were all converted to mass units, and negative values were replaced with 0.001 to abide by software limitations, as discussed in Section 3.3.1. Results of the ANOVA analyses are provided in Appendix B.3 and summarized below.

No VOCs were found to be present in downgradient wells at statistically higher concentrations than in upgradient wells. However, the concentrations of several metals are statistically higher in samples from downgradient wells compared to those from upgradient wells. These results are summarized in Table 3–11. Most importantly, of those constituents present at statistically significant higher concentrations in downgradient wells than in upgradient wells, none exceed the highest of the RFCA surface water action level, PQL, or Temporary Modification specified in the RFCA Attachment 5 (CDPHE, DOE, and EPA 2003). Monitoring will continue and future metals data will be assessed for statistical trend in these downgradient wells; due to data limitations, this is currently not feasible.

Table 3–11. Results of Ground Water ANOVA at the Present Landfill

Analyte	73005	73105	73205	Comments
Antimony	x	x	x	
Arsenic	x	x	x	
Barium		x		
Beryllium		x	x	
Boron	x	x	x	
Cadmium	x			
Chromium		x	x	
Copper	x	x	x	
Lead	x	x	x	
Lithium	--	x	x	Insufficient data for statistical evaluation at 73005
Manganese		x	x	
Molybdenum	--	x	x	Insufficient data for statistical evaluation at 73005
Nickel			x	
Selenium	x		x	
Silver	x	x	x	
Strontium	--	x	x	Insufficient data for statistical evaluation at 73005
Thallium	x	x	x	
Tin	--	x	x	Insufficient data for statistical evaluation at 73005
Uranium	--	x	x	Insufficient data for statistical evaluation at 73005

Note: x = analyte is present in ground water at a statistically significant higher concentration in the indicated downgradient well compared to upgradient wells. -- = see comment.

Ground water quality at the PLF is impacted on the upgradient side by VOCs from the PU&D Yard Plume. Data from 2006 from downgradient RCRA wells show several VOCs were detected in downgradient ground water. Validated detections are summarized in Table 3–12, but again, no VOCs show a statistically-significant increase in concentration from upgradient to downgradient wells.

Ground water flow at the PLF is strongly affected by the GWIS, which diverts ground water flow around the perimeter of the PLF rather than through the wastes. The GWIS includes a slurry wall and perforated drain around the upgradient and side-gradient perimeter of the PLF, and acts to isolate ground water within the PLF from that outside the PLF. (Refer to the previously-published reports referenced earlier in this section for more detail on the GWIS and related discussions.) Previous RCRA and Groundwater Annual Reports have confirmed the effectiveness of this isolation. Because the GWIS is located between the upgradient PLF RCRA wells and the downgradient PLF RCRA wells, estimating seepage velocities as discussed in Section 3.3.4 between those sets of wells is not appropriate.

Table 3–12. VOCs detected in 2006 in Downgradient Wells at the Present Landfill

Well	Sample Date	Analyte	Result	Units	Lab Qualifier
73005	4/19/2006	Acetone	6.9	µg/L	J
73105	10/10/2006	1,3-Dichlorobenzene	0.65	µg/L	J
73105	4/19/2006	Acetone	3.9	µg/L	J
73105	3/6/2006	Chloroform	0.45	µg/L	J
73105	4/19/2006	Chloroform	0.3	µg/L	J
73105	3/6/2006	Chloromethane	0.43	µg/L	J
73105	8/30/2006	m,p-Xylene	2.4	µg/L	
73105	4/19/2006	Toluene	0.49	µg/L	J
73105	8/30/2006	Toluene	0.63	µg/L	J
73205	4/19/2006	Acetone	60	µg/L	
73205	3/6/2006	Chloromethane	0.65	µg/L	J
73205	4/19/2006	Toluene	0.7	µg/L	J

Note: J = analyte detected, result is estimated.

No validation qualifiers were attached to these results.

3.4.2 Original Landfill

The OLF is located within the former IA OU south to southwest of the former 400 Area, between former Cactus Ave. on the north and Woman Creek on the south. The OLF operated as a dump from the 1950s until 1968, when the PLF was opened.

Activities to close the OLF were completed in 2005. Closure included abandoning wells, removing debris, regrading the ground surface, and adding a soil cover. Refer to K-H (2005b) for details on closure of the OLF.

During negotiations to close the OLF, RCRA was identified as an applicable or relevant and appropriate requirement for the facility. As a result of these negotiations, four wells were identified to monitor the OLF, three of which were installed in 2005.

Ground water monitoring requirements at the OLF were consistent over the course of the year, and are outlined in the 2006 IMP (DOE 2006c). Figure 3–1 displays the ground water monitoring network at the OLF. Monitoring performed in 2006 is summarized in Table 3–13.

Table 3–13. RCRA Ground Water Sampling Performed in 2006 at the OLF

Well	Location	Q1	Q2	Q3	Q4
P416589	Upgradient	V, M, S	V, M, S	V, M, S	V, M, S
80005	Downgradient	V, M, S	V, M, S	V, M, S	V, M, S
80105	Downgradient	V, M, S	V, M, S	V, M, S	V, M, S
80205	Downgradient	V, M, S	V, M, S	V, M, S	V, M, S

Notes:

Q = quarter.

V = VOCs, M = metals (which includes U), S = semivolatile organic compounds.

Only RCRA wells supporting the PLF are listed; other wells in the area (such as Sentinel and Evaluation wells) are omitted because they are not a part of the RCRA monitoring network.

The RCRA monitoring network at the OLF comprises one upgradient and three downgradient wells. A year of quarterly analytical data (i.e., four sets of quarterly samples) are required to determine the baseline, and the same quantity of data are needed to perform the upgradient-downgradient statistical comparisons. This 2006 report represents the first annual report to present these analyses for the post-closure network, due to these data requirements.

In addition to monitoring and evaluating these wells similar to RCRA wells (i.e., on a quarterly basis, and evaluating the resulting analytical data via upgradient-downgradient comparisons), the three downgradient wells are also monitored and evaluated in the manner of Sentinel wells at the RFS. Specifically, data from these wells are statistically evaluated using 85th percentile concentrations to compare against surface water standards, and data trends are constructed as warranted to determine a need for action. This type of evaluation requires a minimum of eight data points for each well-analyte combination, in accordance with the IMP, and cannot yet be performed for the OLF wells due to data insufficiency. It is anticipated that the Sentinel well evaluation method will be feasible for the 2007 annual report.

Statistical evaluation of the analytical data from the OLF was performed using all non-rejected data for upgradient and downgradient RCRA wells. An interwell comparison was made (i.e., comparing the upgradient well against downgradient wells) in accordance with the OLF M&M Plan (DOE 2006a), using the ANOVA procedure as run using the Sanitas™ software package. As at the PLF, non-parametric ANOVA was required for most analytes. U data were all converted to mass units, and negative values were replaced with 0.001 to abide by software limitations, as described in Section 3.3.1. Results of the ANOVA analyses are provided in Appendix B.3 and summarized below.

No VOCs were found to be present in downgradient wells at statistically higher concentrations than in upgradient wells. However, the concentrations of several metals are statistically higher in samples from downgradient wells compared to those from upgradient wells. These results are summarized in Table 3–14. Of those constituents present at statistically-significant higher concentrations in downgradient wells than in upgradient wells, only U exceeds the highest of the RFCA surface water action level, PQL, or Temporary Modification specified in the RFCA Attachment 5 (CDPHE, DOE, and EPA 2003). This is to be expected, given the typically higher concentrations of U in ground water relative to surface water. The concentrations do not exceed the U threshold in the IMP (DOE 2006c). Natural U concentrations are seen to vary dramatically over very short distances in other areas (e.g., from well 99305 to well 99405), so the fact that U is higher in well 80205 than the other wells is not necessarily indicative of contamination. However, special analytical methods (high-resolution ICP/MS or TIMS) will be employed in 2007 to determine whether the ground water here is affected by anthropogenic U.

Table 3–14. Results of Ground Water ANOVA at the Original Landfill

Analyte	80005	80105	80205
Boron	x	x	x
Lithium	x	x	x
Manganese		x	
Strontium		x	x
Uranium			x

Note: x = analyte is present in ground water at a statistically significant higher concentration in the indicated downgradient well compared to upgradient wells.

Data reported in 2006 from downgradient RCRA wells at the OLF show several VOCs were detected in downgradient ground water, though again not at statistically higher concentrations than in the upgradient well. Validated detections are summarized in Table 3–15.

Table 3–15. VOCs Detected in 2006 in Downgradient Wells at the Original Landfill

Well	Sample Date	Analyte	Result	Units	Lab Qualifier
80105	2/28/06	Bis(2-ethylhexyl) phthalate	3.8	µg/L	J
80105	8/31/06	m,p-Xylene	2.4	µg/L	
80205	6/5/06	1,2,4-Trichlorobenzene	0.34	µg/L	JB

Note: J = analyte detected, result is estimated. B = chemical detected in method blank. No validation qualifiers were attached to these results.

Bis(2-ethylhexyl) phthalate and m,p-xylene are also reported in samples collected in 2006 from upgradient well P416589.

Ground water flow at the OLF is not affected by controls such as the GWIS at the PLF. Ground water flows beneath the pediment surface north of the OLF in a general west to east direction. As it nears the southern edge of the pediment, ground water is diverted to a more south-southeasterly direction. This latter flow direction applies to ground water moving through the OLF.

Ground water flow velocities were calculated (see Section 3.3.4 and Table 3–9) for OLF well pair P416589 (the upgradient well) and 80105 (the middle downgradient well). The resulting estimates for the travel time from the upgradient to downgradient well range from just over 2 years when ground water is present within the surficial materials (i.e., the “alluvium”), and approximately 4 ½ years when it is within the claystone bedrock screened by the upgradient well. Both of these calculations were performed because during the second quarter of 2006, the ground water in the upgradient well was below the bedrock contact (with the bedrock at this location defined as claystone); in the fourth quarter, it was within the Rocky Flats Alluvium. Because the cover on the landfill is reworked Rocky Flats Alluvium, which almost certainly has a higher hydraulic conductivity, these travel times may be overestimations for pure water, though any contaminants that may be present would likely be retarded significantly.

Seeps are also present at the OLF, and have been observed in this area for decades (as well as being suggested on aerial photographs taken before the RFP came into existence). Additional discussion of these seeps is provided in Section 7.3.2.

3.5 Other Issues Related to Rocky Flats Ground Water in 2006

This section summarizes some of the more notable events, activities, and conditions related to ground water at the RFS in 2006.

3.5.1 Slump South of B991

During expansion and development of the PA in the late 1970s-early 1980s, a valley south of former B991 was filled to provide a uniform surface that would be easier to monitor for security

purposes. A French drain was installed at the base of the up to 30 feet of fill to stabilize the artificial hillside that was constructed in the former valley, and the drain was equipped with an outfall that was later given the identification SW056. Water samples collected from the outfall showed elevated concentrations of VOCs, including PCE, TCE, cis-1,2-DCE, and vinyl chloride. The source of these VOCs is thought to be the IA Plume, as the corridor in which the French drain resides overlaps many other utility corridors that extend into various regions of the former IA. As a part of Site closure it was necessary to address this outfall, as water flowed directly from it into the future FC-4 wetland. The action that was agreed upon by the closure contractor, DOE, and the regulators was to remove the outfall portion of the drain, interrupt the east-west portion of the drain, and backfill the interrupted portion with lower-permeability materials (cement grout) and HRC. One additional requirement was to install a monitoring well immediately downgradient (north) of the east-west drain and upgradient (west) of the point at which that drain had been interrupted. That well is 45605 (Figure 3–1).

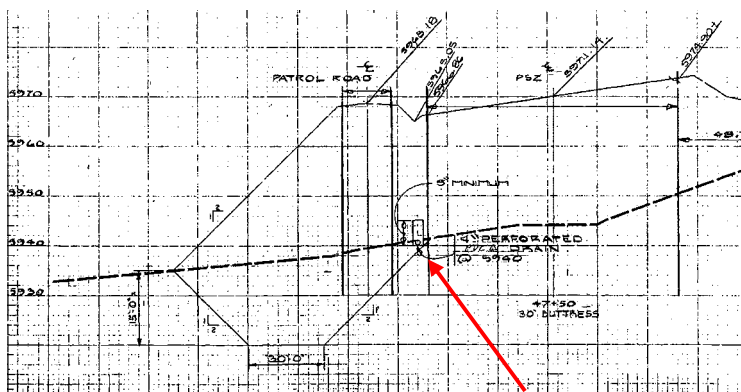
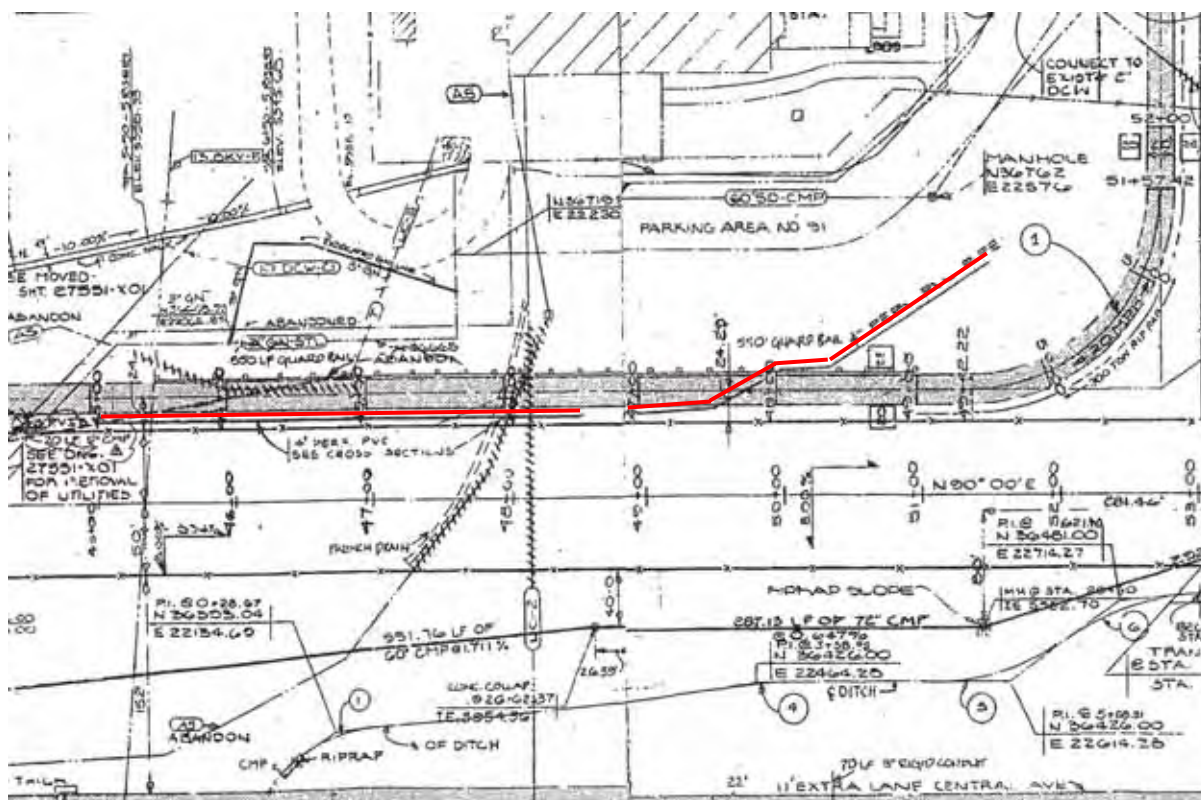
Because the drain outfall has been removed, water that is collected by the remaining portion of the French drain to the west has no defined outlet. This has allowed the collected ground water to saturate the artificial hillside, causing it to become destabilized. Slumping was first apparent in early January 2006 when small cracks were observed across the surface of the ground where the excavation formed to remove the outfall and interrupt the drain had been backfilled. These cracks broadened, extended, and multiplied throughout the year, accompanied by increasing horizontal and vertical displacement. Through discussions with the regulators, a resolution has been devised. Because protecting the integrity of this hillside is not necessary to protect the remedy itself, the slump is being allowed to continue to develop. When movement stops or is sufficiently reduced to allow it, the hillside will be regraded and seeded to address safety and aesthetic concerns. (This will not be done until movement is complete or has slowed enough to limit the need for repeated grading efforts.) If necessary, the well will be replaced after regrading has been completed.

The figures below provide a summary of the history and development of this slump.

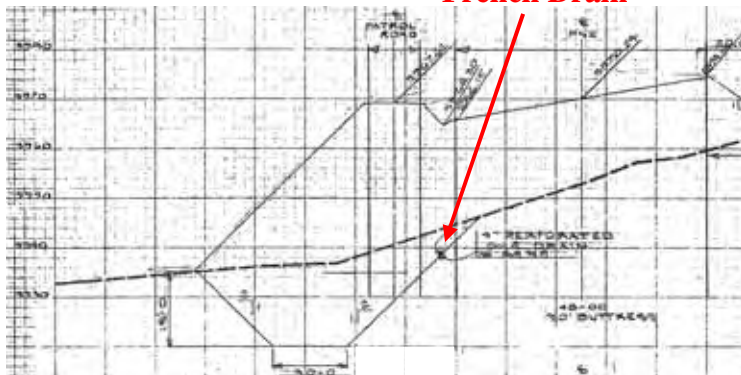


Top left: Water issuing from pipe at SW056. This pipe was removed during closure, eliminating the outlet for water collected by the French drain. Top right: Former B991 and the valley that was filled to enhance security in the late 1970s. Photo taken in the late 1960s; also evident is OBP#2 (dark patch to right of valley) and active storage at 903 Pad (lower right, below OBP#2). Bottom: Same area in 1988, after security upgrades that filled the valley. Approximate axis of valley is indicated.

Figure 3–31. Historic Photographs of SW056 and Associated Area



French Drain



Top drawing: Two merged “as-built” drawings showing utilities in the area generally south of B991, the southwest corner of which is at the top of the drawing and is shown with hatching. To enhance its visibility, the French drain is highlighted with a red line that is slightly offset from the actual drain; the drain’s construction is described on the drawing as 4-inch perforated PVC. Note drawing inaccuracies: The outfall (SW056) was not present at the indicated point (far right end of drain, near circled number 1), but was instead just south of the word “Area” in “Parking Area No 91”; and the French drain was presumably continuous and did not have the short gap that is shown. (The faint vertical line at the right edge of this gap is where the two drawings are merged.) Bottom two drawings: “As-built” cross-section drawings (nos. 47.50 and 48.00) of the constructed hillside in the vicinity of SW056, showing the drain to have been installed approximately 28 to 30 feet below the surface of the Patrol Road that was placed on top of the hillside. Heavy dashed line indicates former ground surface.

Figure 3–32. “As-built” Drawings of French Drain and Constructed Hillside



Top photo: Conditions on June 6, 2005. The constructed hillside is the area covered with green grass. Future FC-4 wetland is at its base, and SW056 is located as shown, just left of the line of willows on the valley floor. The site of former B991 is across FC-4 from the hillside and SW056, on the center-right edge of the photo. FC-5 (the line of gray rip-rap) enters from the left and joins FC-4 near the center of the photograph. Site closure activities are still in progress at this time, as indicated by the presence of heavy equipment and former B891 in the background. Bottom photos: Ground surface on January 12, 2006, showing developing fractures. Well 45605 is visible in the lower right photo.

Figure 3–33. Photographs of Hillside and Ground Surface Prior to Slump Development



Top photo: Panoramic shot of slump from B991 hillside on May 10, 2006. Person is faintly visible near base of constructed hillside in left portion of photo; the brown, sparsely-vegetated swath across which this person is walking is the extent of the excavation formed to remove the SW056 pipe and interrupt the French drain. The concrete pad for monitoring well 45605 is visible as a light spot at the top right corner of this area of sparse vegetation. Maximum vertical displacement at main fracture on this date was approximately 12 ft. Middle photo: Future FC-4 wetland and area of uplift caused by rotational slumping; as the ground surface above and to the right (south) moves downward, the floor of the wetland against that hillside moves up and out (toward the north). The area where the approximately 5 ft. 4 in.-tall person is standing used to be even with the floor of FC-4, as was evident from water stains on the erosion matting covering the ground surface; the line of willows shown on the top photo of Figure 3–33 extend from the floor of the future wetland across the uplifted area just past the person in the photo. Well 45605 is visible at top right; the orientation of the surface protection for this well is clearly no longer vertical. Bottom photo: Slump on February 13, 2007. Maximum displacement at main fracture on this date was approximately 16 ft. Displacement along other fractures north (in the direction of the valley floor) of the main fracture also increased through 2006.

Figure 3–34. Photographs of Slump During Development

3.5.2 SPPTS Investigations

Section 3.3.2.3 summarizes investigations performed at the SPPTS and the results of those investigations. This section will not reiterate that discussion, but will instead summarize the data that were gathered during the water quality component of these investigations and the treatability study that followed.

The investigations of the SPPTS generally included physical and chemical components. The physical components involved assessment of valve configurations (which led to the use of heavy equipment to restore access to the valves) and the condition of the media and plumbing (which led to extensive plumbing repairs). The chemical component included sampling of various points on the system to determine the effects of the physical activities.

Water samples were collected from numerous locations at the SPPTS. Included were the traditional influent sampling location (SPPMM02, a.k.a. piezometer 71099), the actual influent location (SPIN, the collection well from which the pump delivers water to the treatment cells), the effluent location (SPPMM01), and the discharge gallery (SPP Discharge Gallery). In addition, several points within the treatment cells were sampled by inserting tubing in the vent risers associated with cell influent and cell effluent pipes. Sampled locations included the west cell (Cell 1) influent, west cell effluent (later assigned the identification SPWEF), east cell (Cell 2) influent (later assigned the identification SPEIN), and east cell effluent.

Samples were shipped to the Environmental Sciences Laboratory (ESL) in Grand Junction, Colorado, which is operated for DOE-LM by the S.M. Stoller Corp. As such, the data are used as “field screening data” to evaluate general trends and effectiveness, with confirmatory samples collected and shipped to a contract laboratory when needed.

The results generated by the ESL are provided in Table 3–16.

A treatability study was also performed at the SPPTS. The objective of this study was to determine if a simpler, more efficient, and less management-intensive system could be designed.

A study facility (a modified, enclosed utility trailer) was stationed at the SPPTS. Solar panels were erected and used to recharge batteries that drove the equipment. Untreated influent was pumped through four columns and effluent concentrations of nitrate were measured. The columns compared different substrates: two were pea gravel, and two were engineered, high surface-area plastic packing beads. All four were inoculated with denitrifying bacteria, and the influent directed to one column of each type of substrate was augmented with ethanol, the carbon source evaluated as a nutrient for the bacteria.

Table 3–16. Field Screening Results From the SPPTS

Sample Location	Sample Date	pH (field)	U (µg/L, ESL)	U (µg/L, CL)	Alkalinity (mg/L as CaCO ₃ ; ESL)	Nitrate as N (mg/L; field)	Nitrate as N (mg/L; IC; ESL)	Nitrate as N (mg/L; CL)	Ammonia as N (mg/L; ESL)	Total Iron (mg/L; field)	TOC (mg/L; ESL)	N-BaRT (cfu/mL; ESL)	Nitrite as N (mg/L; ESL)	pH (ESL)	Total Iron (mg/L; flame)
SPPMM02	1/19/2006		29.02												
SPPMM02	1/23/2006			36			272	220	1 (U)						
SPPMM02	2/8/2006		31.5				270								
SPPMM02	2/28/2006		26.2				264								
SPPMM02	3/28/2006		39.3		320		274				17.2				
SPPMM02	3/30/2006	6.86	27.3		370	286	257			1.02	5.3				
SPPMM02	4/6/2006		23.6				265								
SPPMM02	4/12/2006		23.3				268								
SPPMM02	4/17/2006		24.6				265								
SPPMM02	5/1/2006		27.2				219								
SPPMM02	5/8/2006		36.3				139								
SPPMM02	5/17/2006		25.4				243								
SPPMM02	5/22/2006		27.3				247								
SPPMM02	5/29/2006		24.1				270								
SPPMM02	6/12/2006		26.4				259								
SPPMM02	6/19/2006		23.9				258								
SPPMM02	6/26/2006		23.9				258								
SPPMM01	1/19/2006		0.92												
SPPMM01	1/23/2006			1.5			460	390	19						
SPPMM01	2/8/2006		15.8				435								
SPPMM01	2/28/2006		37.3				331								
SPPMM01	3/28/2006		19.9		150		328				4.6				
SPPMM01	3/30/2006	7.59	2.63		60	324	304			0.12	3.8				
SPPMM01	4/6/2006		2.76				266								
SPPMM01	4/12/2006		0.22				280								
SPPMM01	4/17/2006		0.1				224								
SPPMM01	5/1/2006		2.6				341								
SPPMM01	5/8/2006		2.5				296								
SPPMM01	5/17/2006		0.2				263								
SPPMM01	5/22/2006		0.6				271								
SPPMM01	5/29/2006		4.8				244								
SPPMM01	6/12/2006		5.2				293								

Table 3–16 (continued). Field Screening Results From the SPPTS

Sample Location	Sample Date	pH (field)	U (µg/L; ESL)	U (µg/L; CL)	Alkalinity (mg/L as CaCO ₃ ; ESL)	Nitrate as N (mg/L; field)	Nitrate as N (mg/L; IC; ESL)	Nitrate as N (mg/L; CL)	Ammonia as N (mg/L; ESL)	Total Iron (mg/L; field)	TOC (mg/L; ESL)	N-BaRT (cfu/mL; ESL)	Nitrite as N (mg/L; ESL)	pH (ESL)	Total Iron (mg/L; flame)
SPPMM01	6/19/2006		5.6				275								
SPPMM01	6/26/2006		4.6				252								
SPPMM01	7/11/2006		1.4		130		209		25		7.6		1.48	6.57	0.01
SPPMM01	7/17/2006		4.8				159		20		9.8		0.96		3.27
SPPMM01	7/25/2006		1.9				126		30		12.7		1.47		0.11
SPPMM01	10/26/2006								21						
SPP D. G.	1/19/2006		40.4				673		4						
SPP D. G.	7/11/2006		46.7		240		581		3		8.1		0.474	6.56	0.01 (U)
SPP D. G.	7/17/2006		55.6				556		1		11.5		0.735		0.1
SPP D. G.	7/25/2006		48.9				533		3		7		0.305		0.11
SPP D. G.	10/26/2006								5						
SPIN	3/30/2006	6.65	29.1		400	300	290			0	6.1	1000			
SPIN	4/6/2006		26.4				299								
SPIN	4/12/2006		25.2				242								
SPIN	4/17/2006		23.3				270								
SPIN	5/1/2006		36.2				319								
SPIN	5/8/2006		40.4				321								
SPIN	5/17/2006		36.5				308								
SPIN	5/22/2006		39.4				380								
SPIN	5/29/2006		35.5				302								
SPIN	6/12/2006		33.6				291								
SPIN	6/19/2006		35.1				315								
SPIN	6/26/2006		34.6				324								
SPIN	7/11/2006		41.5		290		329		1 (U)		8.6		0.02	6.69	0.24
SPIN	7/17/2006		43				338		1 (U)		14.9		0.011		1.54
SPIN	7/25/2006		37.1				304		1 (U)		16		0.01		0.32
SPIN	10/26/2006								1 (U)						

Table 3-16 (continued). Field Screening Results From the SPPTS

Sample Location	Sample Date	pH (field)	U (µg/L; ESL)	U (µg/L; CL)	Alkalinity (mg/L as CaCO ₃ ; ESL)	Nitrate as N (mg/L; field)	Nitrate as N (mg/L; IC; ESL)	Nitrate as N (mg/L; CL)	Ammonia as N (mg/L; ESL)	Total Iron (mg/L; field)	TOC (mg/L; ESL)	N-BaRT (cfu/mL; ESL)	Nitrite as N (mg/L; ESL)	pH (ESL)	Total Iron (mg/L; flame)
SPPTS W.C. in.	3/30/2006	6.57	29.3		400	246	244			0.08	12.2	1000			
SPPTS W.C. ef.	3/30/2006	6.56	36		510	274	272			0.63	10.8	10000			
SPPTS W.C. ef.	7/11/2006		36		470		286		1 (U)		12.3		0.067	6.44	9.55
SPPTS W.C. ef.	7/17/2006		11.7				14		1 (U)		21		0.022		4.8
SPPTS W.C. ef.	7/25/2006		8.1				0.25		1 (U)		22		0.005 (U)		33.9
SPPTS W.C. ef.	10/26/2006								1 (U)						
SPPTS E.C. in.	3/30/2006	6.84	42.9		320	325	343			0	11.2				
SPPTS E.C. in.	7/11/2006		28.9		220		245		7		11.1		2.49	6.49	0.92
SPPTS E.C. in.	7/17/2006		24				149		1 (U)		22		0.012		0.81
SPPTS E.C. in.	7/25/2006		21.7				146		1 (U)		6.4		0.005 (U)		15.2
SPPTS E.C. in.	10/26/2006								1						
SPPTS E.C. ef.	3/30/2006	8.45	2.99		40	323	321			0.1	4	10000			
GS13	5/1/2006		19.7				76								
GS13	5/8/2006		21.3				74								
GS13	5/17/2006		19.8				66								
GS13	5/22/2006		22.4				63								
GS13	5/29/2006		26.4				55								
GS13	6/12/2006		32.6				58								
GS13	10/26/2006								1 (U)						

NOTES:

field = field measurement; ESL = Environmental Sciences Laboratory measurement; CL = Contract Laboratory measurement.

U = uranium, ammonia = total ammonia; TOC = total organic carbon, N-BaRT: "N" signifies denitrifying bacteria, BaRT = biological activity reaction test; N = nitrogen;

µg/L = micrograms per liter; mg/L = milligrams per liter; cfu/mL = colony forming units per milliliter.

CaCO₃ = calcium carbonate; IC = ion chromatography; flame = flame atomic absorption spectrometry.

D.G. = Discharge Gallery; W.C. in. = west cell influent; W.C. ef. = west cell effluent; E.C. in. = east cell influent; E.C. ef. = east cell effluent.

(U) = analyte not detected at indicated level.

Unfortunately, the studies experienced difficulties that led to their discontinuation before they could be completed. After several weeks of operation, it was apparent that the columns were not behaving as expected because negligible nitrate removal was occurring. Tracer tests were performed and revealed that instead of the 8-hour designed residence time, water was short-circuiting through the columns in as little as 10 minutes. The studies were paused and possible alternatives were considered.

The study apparatus was then re-engineered for batch-mode operation, in which influent would be pumped into the columns, then the columns would be sealed for 8 hours, then water would be exchanged and later another 8-hour batch test would be run. Shortly after this solution was devised and put in place, an extended period of very cold temperatures caused the columns and their water jackets to freeze. (Influent was also circulated through large barrels in which the columns were replaced; this was done to stabilize temperatures. For freeze protection, due to the limited power available only a low-wattage light bulb could be used; it was placed within the insulated study facility and connected to a timer that activated it during the colder night-time hours.) Because of these continuing difficulties, the studies were halted for additional reconsideration.

Due to winter weather, it was decided to forego completion of the current studies and use information they provided to design new, larger studies. Those study designs will be finalized and the studies will be performed in spring and summer 2007.

The report on the aborted studies is attached as Appendix D.

3.5.3 Seeps

Several seeps were observed over the course of 2005 that warrant special mention. Those present on the OLF are discussed separately (refer to Section 7.3.2).

A seep was observed at the northeastern end of the fractures associated with the slump at former SW056 (see Section 3.5.1). Standing water was visible inside a fracture during an inspection of the slump on August 2, 2006. This inspection followed a precipitation event, however, so it was not certain whether the water was seepage or precipitation. Subsequent inspections showed it to be seepage.

The location in which this seep is present has long been marked by lush vegetation (willows and thick grass). Close inspection of aerial photographs from 1937 and 1951 show even more lush vegetation at that time, which precedes development of the RFP. Therefore, the appearance of this seep would seem to represent a condition that was normal prior to the existence of the Site, as opposed to a “new” seep.

Another seep was observed in the fall of 2006 on the hillside forming the eastern margin of the FC-1 basin, near the southwest corner of the former B371/374 complex. The ground at the seep is covered with railroad ballast (dark gray, angular gravel), and it appeared the seep might be issuing from this deposit. At the time the seep was observed, a large puddle was present south of former B371, east of and topographically higher than the location of the seep.

Aerial photos of the area taken during B371/374 closure were examined. It was found that the ballast and seep occur at the western end of the former rail line that was used to transport demolition/closure debris from the Site, and the puddles that had been present were overlying part of the former rail line. It was therefore concluded that the railroad ballast was covered with backfill but not removed or extensively disrupted during final closure and regrading efforts in this area, and this subsurface deposit of gravel acts to drain accumulated surface water toward FC-1, where it issues as the seep that was observed.

3.5.4 No-Purge Sampling

After DOE-LM accepted control of the Site, a study was begun to determine the feasibility of using different sampling methods at wells that typically go dry during the pre-sampling purge. This purging activity is intended to remove stagnant, non-representative water from a well so that the sample represents fresh ground water. However, by purging extremely low-producing wells, often there is insufficient recharge to collect a sample within the allotted time (for VOCs, this is 48 hours after purging). DOE-LM and some other entities have on occasion employed a “no-purge” sampling technique at such wells, and the no-purge method has been reported to be applicable to carefully selected fuel-hydrocarbon sites (Newell et al. 2000). (See also WSPA 1996, and Barcelona 1997 for additional discussion of this technique.) In this use of the term “no purge,” samples are collected from water initially present within the well casing, rather than purging that water and collecting the recharge (if any); this latter process is the traditional sampling method at Rocky Flats.

Parallel sampling at the Site was attempted in the fourth quarter of 2005 at six wells, and in the second and fourth quarters of 2006 in up to eight wells. These specific wells were selected because they often fail to recover during sampling. The intent was to collect a sample using the no-purge method, then purge the well and collect a second sample (termed the purge sample in this discussion). In most cases, the analytical suite was VOCs, but metals and/or nitrate were included at some locations. The goal of this effort is to evaluate whether a transition to no-purge sampling for low-producing wells would be acceptable from the perspective of data usability and representativeness.

Many of the wells selected for this study did not provide adequate water to meet the study objectives. In some cases (e.g., wells 4787 and 4887) they were dry and provided no samples; in other cases, they provided the no-purge sample but not the purge sample. Further complication resulted from the need to return to some wells at a later date to collect the purge samples, because recharge was so slow. The resulting temporal gap between samples ranged from 1 day to over 6 weeks. Such a long period between samples clearly raises the question of whether both such samples can be considered to represent the same ground water.

Analytical results of these samples were assembled. Only paired samples were included in the assessment; if a well did not produce both the no-purge and purge samples, analytical data for the event were eliminated from consideration.

Table 3–17 provides a summary of analytical data from this study.

Table 3–17. Comparison of Analytical Results From Samples Collected Using No-Purge and Purge Sampling Methods

Well	Sample Date	Analyte Name	Result	Units	Lab Qualifier
00797-NP	12/12/2005	Trichloroethene	0.58	µg/L	J
00797-P	12/14/2005	Trichloroethene	0.2	µg/L	U
00797-NP	12/12/2005	Uranium	26	µg/L	J
00797-P	12/14/2005	Uranium	25	µg/L	J
10594-NP	12/12/2005	Methylene chloride	0.1	µg/L	U
10594-P	12/14/2005	Methylene chloride	0.41	µg/L	J
10594-NP	12/12/2005	Nitrate + Nitrite as Nitrogen	0.07	mg/L	
10594-P	12/14/2005	Nitrate + Nitrite as Nitrogen	0.04	mg/L	B
10594-NP	12/12/2005	Trichloroethene	0.51	µg/L	J
10594-P	12/14/2005	Trichloroethene	0.2	µg/L	U
10594-NP	12/12/2005	Uranium	91	µg/L	J
10594-P	12/14/2005	Uranium	95	µg/L	J
90399-NP	12/12/2005	1,1,1-Trichloroethane	0.15	µg/L	U
90399-P	12/13/2005	1,1,1-Trichloroethane	0.17	µg/L	J
90399-NP	12/12/2005	1,1-Dichloroethene	1.3	µg/L	
90399-P	12/13/2005	1,1-Dichloroethene	1.3	µg/L	
90399-NP	12/12/2005	Carbon tetrachloride	250	µg/L	D
90399-P	12/13/2005	Carbon tetrachloride	310	µg/L	D
90399-NP	12/12/2005	Chloroform	29	µg/L	D
90399-P	12/13/2005	Chloroform	37	µg/L	
90399-NP	12/12/2005	cis-1,2-Dichloroethene	3.8	µg/L	
90399-P	12/13/2005	cis-1,2-Dichloroethene	3.3	µg/L	
90399-NP	12/12/2005	Methylene chloride	0.1	µg/L	U
90399-P	12/13/2005	Methylene chloride	0.44	µg/L	J
90399-NP	12/12/2005	Tetrachloroethene	8.6	µg/L	
90399-P	12/13/2005	Tetrachloroethene	9.2	µg/L	
90399-NP	12/12/2005	Trichloroethene	280	µg/L	D
90399-P	12/13/2005	Trichloroethene	320	µg/L	D
10992-NP	5/31/2006	Acetone	1.9	µg/L	U
10992-P	5/31/2006	Acetone	99	µg/L	
10992-NP	5/31/2006	Methylene chloride	0.32	µg/L	U
10992-P	5/31/2006	Methylene chloride	0.46	µg/L	JB
21505-NP	5/24/2006	1,1-Dichloroethane	1.2	µg/L	
21505-P	5/24/2006	1,1-Dichloroethane	0.6	µg/L	J
21505-NP	5/24/2006	1,1-Dichloroethene	1.5	µg/L	
21505-P	5/24/2006	1,1-Dichloroethene	0.6	µg/L	J
21505-NP	5/24/2006	Acetone	1.9	µg/L	U
21505-P	5/24/2006	Acetone	6.4	µg/L	J
21505-NP	5/24/2006	cis-1,2-Dichloroethene	3.2	µg/L	
21505-P	5/24/2006	cis-1,2-Dichloroethene	1.5	µg/L	
21505-NP	5/24/2006	Tetrachloroethene	4.6	µg/L	
21505-P	5/24/2006	Tetrachloroethene	1.3	µg/L	
21505-NP	5/24/2006	Toluene	0.17	µg/L	J
21505-P	5/24/2006	Toluene	0.17	µg/L	U
21505-NP	5/24/2006	Trichloroethene	25	µg/L	
21505-P	5/24/2006	Trichloroethene	8.9	µg/L	
73005-NP	10/10/2006	1,3-Dichlorobenzene	2.1	µg/L	

Table 3–17 (continued). Comparison of Analytical Results From Samples Collected Using No-Purge and Purge Sampling Method

Well	Sample Date	Analyte Name	Result	Units	Lab Qualifier
73005-P	10/11/2006	1,3-Dichlorobenzene	0.16	µg/L	U
73005-NP	10/10/2006	Aluminum	18	µg/L	U
73005-P	11/28/2006	Aluminum	95.2	µg/L	B
73005-NP	10/10/2006	Arsenic	4.4	µg/L	U
73005-P	11/28/2006	Arsenic	7.1	µg/L	B
73005-NP	10/10/2006	Barium	100	µg/L	
73005-P	11/28/2006	Barium	97	µg/L	B
73005-NP	10/10/2006	Boron	29	µg/L	B
73005-P	11/28/2006	Boron	39.5	µg/L	
73005-NP	10/10/2006	Cadmium	0.45	µg/L	U
73005-P	11/28/2006	Cadmium	1.8	µg/L	B
73005-NP	10/10/2006	Cobalt	1.2	µg/L	B
73005-P	11/28/2006	Cobalt	1	µg/L	U
73005-NP	10/10/2006	Lithium	84	µg/L	
73005-P	11/28/2006	Lithium	85.5	µg/L	B
73005-NP	10/10/2006	Manganese	14	µg/L	
73005-P	11/28/2006	Manganese	18.3	µg/L	
73005-NP	10/10/2006	Selenium	10	µg/L	B
73005-P	11/28/2006	Selenium	6	µg/L	U
73005-NP	10/10/2006	Strontium	750	µg/L	
73005-P	11/28/2006	Strontium	895	µg/L	
73005-NP	10/10/2006	Thallium	4.9	µg/L	U
73005-P	11/28/2006	Thallium	14.7	µg/L	B
73005-NP	10/10/2006	Uranium	16	µg/L	B
73005-P	11/28/2006	Uranium	52.3	µg/L	J
73005-NP	10/10/2006	Zinc	6.4	µg/L	B
73005-P	11/28/2006	Zinc	6.8	µg/L	B
90399-NP	6/13/2006	1,1-Dichloroethene	1	µg/L	
90399-P	6/13/2006	1,1-Dichloroethene	1.2	µg/L	
90399-NP	11/1/2006	1,1-Dichloroethene	0.34	µg/L	J
90399-P	11/2/2006	1,1-Dichloroethene	0.76	µg/L	J
90399-NP	6/13/2006	Acetone	5.6	µg/L	J
90399-P	6/13/2006	Acetone	2.7	µg/L	J
90399-NP	6/13/2006	Carbon tetrachloride	210	µg/L	
90399-P	6/13/2006	Carbon tetrachloride	240	µg/L	
90399-NP	11/1/2006	Carbon tetrachloride	120	µg/L	
90399-P	11/2/2006	Carbon tetrachloride	140	µg/L	
90399-NP	6/13/2006	Chloroform	39	µg/L	
90399-P	6/13/2006	Chloroform	43	µg/L	
90399-NP	11/1/2006	Chloroform	28	µg/L	
90399-P	11/2/2006	Chloroform	29	µg/L	
90399-NP	6/13/2006	cis-1,2-Dichloroethene	3.8	µg/L	
90399-P	6/13/2006	cis-1,2-Dichloroethene	4.4	µg/L	
90399-NP	11/1/2006	cis-1,2-Dichloroethene	2.4	µg/L	
90399-P	11/2/2006	cis-1,2-Dichloroethene	2.5	µg/L	
90399-NP	11/1/2006	Styrene	1.2	µg/L	
90399-P	11/2/2006	Styrene	1.1	µg/L	

Table 3–17 (continued). Comparison of Analytical Results From Samples Collected Using No-Purge and Purge Sampling Method

Well	Sample Date	Analyte Name	Result	Units	Lab Qualifier
90399-NP	6/13/2006	Tetrachloroethene	8.2	µg/L	
90399-P	6/13/2006	Tetrachloroethene	9.1	µg/L	
90399-NP	11/1/2006	Tetrachloroethene	3.5	µg/L	
90399-P	11/2/2006	Tetrachloroethene	3.9	µg/L	
90399-NP	6/13/2006	Trichloroethene	350	µg/L	
90399-P	6/13/2006	Trichloroethene	380	µg/L	
90399-NP	11/1/2006	Trichloroethene	170	µg/L	
90399-P	11/2/2006	Trichloroethene	180	µg/L	
90402-NP	6/12/2006	1,1-Dichloroethene	0.27	µg/L	J
90402-P	6/12/2006	1,1-Dichloroethene	0.24	µg/L	J
90402-NP	6/12/2006	Acetone	5.1	µg/L	J
90402-P	6/12/2006	Acetone	2.4	µg/L	J
90402-NP	6/12/2006	Carbon tetrachloride	10	µg/L	
90402-P	6/12/2006	Carbon tetrachloride	10	µg/L	
90402-NP	6/12/2006	Chloroform	2.7	µg/L	
90402-P	6/12/2006	Chloroform	2.7	µg/L	
90402-NP	6/12/2006	cis-1,2-Dichloroethene	0.24	µg/L	J
90402-P	6/12/2006	cis-1,2-Dichloroethene	0.16	µg/L	J
90402-NP	6/12/2006	Tetrachloroethene	9.7	µg/L	
90402-P	6/12/2006	Tetrachloroethene	11	µg/L	
90402-NP	6/12/2006	Trichloroethene	17	µg/L	
90402-P	6/12/2006	Trichloroethene	16	µg/L	
B206989-NP	10/10/2006	Nitrate + Nitrite as Nitrogen	36	mg/L	
B206989-P	10/10/2006	Nitrate + Nitrite as Nitrogen	35	mg/L	
B206989-NP	10/10/2006	Uranium	110	µg/L	
B206989-P	10/10/2006	Uranium	120	µg/L	

NOTES: Well numbers have -P or -NP suffices attached; -P refers to the purge sample, -NP refers to no-purge samples. Qualifiers: J = estimated; U = analyte not detected; B = analyte detected in blank; D = analysis run at a dilution.

Results gathered during this evaluation were first examined and results for analytes that were not detected in either sample were removed from the data set. The final data set was then assessed statistically using both the ANOVA and Mann-Whitney methods. An interwell comparison was made. No-purge data were assigned upgradient and purge downgradient positions. Both statistical methods found insufficient data to form a conclusion for many analytes, which is not surprising given the maximum possible size of the pool of data was only three samples for each analyte/method/well combination (one each for the three quarters in which samples were collected using both methods).

While the overall results of the study to date are inconclusive, preliminary results for several analytes suggest there is no statistical difference between samples collected using no-purge vs. purge methods. (See Appendix B.3 for the results of this assessment.) However, because the results are not conclusive and because of the significant temporal gap between some samples, this study will be continued into 2007 in an attempt to collect enough data to support a technically-based decision on whether to use no-purge sampling methods at selected poor-producing wells.

End of current text